

THE GEOGRAPHY OF THE SOILS AND AGRICULTURE

OF

HONG KONG

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- by -

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## Chapter I

### GENERAL DESCRIPTION

#### Location and Extent

The Colony of Hong Kong consists of a number of islands and a portion of mainland on the southeast coast of China adjoining Kwangtung Province. Canton, the largest city in South China, lies 90 miles to the northwest and the Portuguese Colony of Macau is situated 40 miles west of Hong Kong on the eastern side of the Pearl river estuary.

The total land area of the Colony is 391 square miles, but there are only 50 square miles of agricultural land; and the remainder is very rugged and mountainous. Hong Kong Island and Kowloon are largely residential or industrial. All of the agricultural areas are in the New Territories, which comprise 355 square miles of land leased from China for a period of 99 years from 1st July 1898. The leased area consists of a substantial mainland section north of Kowloon and 198 nearby islands. (Figs. 1 and 2).

The position of Hong Kong in relation to China and in relation to other countries of the Far East is the key to the importance of the Colony. Trade and industry are the basis of the economy, but with an urban population of



two and a half million it has become important that agriculture in Hong Kong should be intensified and adapted to provide at least a proportion of the food requirements of the city. Unfortunately the agricultural potential is severely limited by the physical conformation of the Colony.

### Physical Features

Numerous earth movements have been involved in the formation of southeast China, and each of these movements is reflected in the confused topography of Hong Kong. Most of the important agricultural areas have been formed during a very recent period of uplift but, although there is active deposition in the west and northwest of the Colony, there are numerous indications that the eastern coastline is being seriously eroded by the sea. (fig. 4).

The largest area of deposition is Deep Bay in the northwest and it is in this district that the richest and most extensive farmland is found. Much of the alluvial material is estuarine or deltaic and may be related to the Canton lowlands round the mouth of the Pearl River.

Deep Bay Depression extends south to Castle Peak Bay and eastward along the Shum Chun River to the Basins of Fanling and Takuling. Most of the alluvial material is derived from fine grained volcanic or metamorphic rock and the textures are predominantly silty. Deposition is still very active and there are numerous marshes round

the shores of Deep Bay. From geomorphological and historical evidence it is apparent that most of the deposition has taken place in historical times and many of the soils two or three miles from the coast still exhibit saline structures though the level of soluble salts is quite low.

South and east of Deep Bay the Colony is largely mountainous with flat land occurring only in long narrow valleys and at the head of inlets. The more important of these valleys are the Lam Tsuen and Shatin on the mainland and Tung Chung on Lantau Island, but there are numerous small patches of cultivated land along the deeply indented coastline. Alignment of these valleys and depressions is determined by geological faults and a NE-SW trend is dominant. In the drowned river valley area of Shatin and Tolo Channel most of the tidal mudflats were cultivable land up to 500 years ago (Barnett, 1959) and the sea is slowly encroaching on the lowlying valleys. The greatest losses occur during typhoons, when the winds are so aligned that they blow directly along the drowned valleys from the sea. Huge waves are built up and whole villages have been washed away.

In contrast with the intensive cultivation and high population density of the alluvial lowlands, the hills are bare and barren with only a few isolated communities in the upper valleys and small plateaus. Three types of

topography are represented in the mountainous areas. In the volcanic peninsulas to the north and south of Tolo Channel there are rolling high plateaus at altitudes of 600 - 1000 feet above sea level, but in the region of porphyry rocks which form the core of the mainland at Tai Mo Shan and the spine of Lantau Island at Tai Yu Shan, the mountains rise in peaks of 2,000 - 3,000 feet above sea level and there are numerous steep sided valleys. The granite areas are strikingly different from either the porphyry or the volcanic areas. Decomposition of the granite produces a material which is easily eroded so that the hills around Tai Lam Chung and Castle Peak are bare of vegetation and deeply gullied.

A striking characteristic of all of the mountainous areas of Hong Kong is the pattern of faults and cleavage lines which has determined the courses of valleys and ridges. The close geographical relationship to southeast China is demonstrated by the NE - SW trend that is revealed in both the geology and the relief.

It is difficult to express the deep dissection of the topography but the relative relief map (fig. 3) may give some impression of the extreme complexity of relief.

In conformity with the fault systems the drainage pattern tends to be rectangular, the main streams flowing

NE - SW and the tributary valleys following NW - SE cleavage lines. The only river of any appreciable size is the Shum Chun, which forms the northwestern boundary of the Colony and flows into Deep Bay. Water is very important both for agriculture and for industry and almost all of the streams have been either diverted for irrigation, or dammed to provide reservoirs for city supply. Only a fractional percentage of reservoir water is available for irrigation but large areas, notably in the Ha Tsuen and Ta Ku Ling areas, would benefit considerably if they could be assured of a winter supply of water for the crops (fig. 4).

#### Climate

Hong Kong may be described as having a monsoon type of climate, but it must be emphasised that the regularity and dependability frequently associated with the term "monsoon" are not characteristic of Hong Kong weather. Lying as it does, just within the Tropics and on the southeastern side of the Asian land mass, the Colony is influenced by the seasonal pressure changes of winter high, and summer low, on the continent, so that the summers are generally hot and wet, and the winters are cold and dry. However, because of its geographical situation as an unprotected peninsula exposed to winds from the Pacific Ocean, there is a strong maritime influence in the climate



of Hong Kong. There are wide variations, both in the annual amount, and in the seasonal distribution, of rainfall (fig. 5).

### Rainfall

In summer the atmosphere is normally unstable and most of the rainfall is derived from thunderstorms, which are caused by local convection; although up to 20<sup>per cent</sup>% of the annual rainfall may be attributed to typhoons. The summer rains show a marked diurnal variation with a maximum in the morning. Vegetable farmers in the Colony adjust their daily schedule to this variation and most of the hand watering of crops is done in the late afternoon and early evening.

A peculiar feature of the summer rainfall is the high intensities which are recorded. More than 12 inches of rain per hour have been recorded and 9 inches per hour is not uncommon. These heavy downpours are associated with thunderstorm clouds of great vertical extent. Rain accompanying typhoons, though frequently heavy and prolonged, never quite reaches record intensities.

Unfortunately, while heavy rain fills the reservoirs, it does not help the farmers, for the streams which irrigate the fields are very short with small catchments and little storage capacity. Heavy showers are, in fact, more damaging than beneficial, flooding the fields and



destroying crops. Farming in Hong Kong, now that vegetables are grown extensively, is more frequently affected by flooding than by drought. Rice, unless the grain is in the milky stage, is relatively unaffected by heavy rainfall or flooding, but few vegetable crops can survive a rainfall intensity of greater than 10.5 inches per hour.

In an average year 90% of the rainfall occurs in the seven summer months from April to October; but winter showers play an important part in the farming economy by permitting catch crops to be grown after the rice has been harvested and by helping maintain the stream flow for irrigation of European type vegetables.

In winter the prevailing winds near the ground blow from ENE and the lower atmosphere is cooled from below and is generally stable. Clouds tend to form in stratified sheets, and precipitation occurs in the form of drizzle or light rain associated with wavelike disturbances in the upper air-flow. There is practically no diurnal variation.

The mountains attract a great deal of rain by orographic lifting of the air stream and the maximum rainfall is recorded in the Tai Mo Shan area, in Lantau, and on the eastern peninsulas. This carries the unfortunate corollary that the lowest rainfall occurs in the lowlying area at the <sup>north-west</sup> NE of the Colony round Deep Bay. If this ?

dry segment could have a higher precipitation, particularly in spring, the agricultural output would be greatly increased. Droughts are very rare in the summer months (May-Sept.), only two such periods being recorded since records began in 1884. They are, however, frequent in the winter months and cause great hardships in the farming areas. Occasionally they are very serious as, for example in the autumn and winter of 1954 when there was an almost continuous drought from the beginning of November to the middle of March, during which time less than one inch of rain fell (fig. 6).

#### Temperature.

Statistics of temperature are not available for the whole Colony but there are significant variations which are apparent from crop responses. The mean minimum temperature for January is  $56.1^{\circ}\text{F}$  recorded at the Royal Observatory in Kowloon, but occasionally in the winter months hoar frost may be seen on the higher ground round Sek Kong, and it is not unknown for crops of sweet potatoes and tomatoes to be severely damaged by frost. In general, Sek Kong valley records winter temperatures some  $5^{\circ}\text{F}$  below, and summer temperatures  $5^{\circ}\text{F}$  above, those of the Royal Observatory.

There is naturally a decrease in temperature with altitude and this effect is intensified by the higher rainfall and greater cloudiness of the mountain tops. The

cooler climate above the 1,500 foot level affects not only the vegetation, but also the soils, and podsolisation may be noted. Experiments are being carried out by the Agriculture, Fisheries and Forestry Department to discover the most suitable crops which may be grown at the upper levels to take advantage of the cooler temperatures and higher rainfall.

On south facing hillsides at lower levels, which are seldom protected by cloud cover, the insolation is intense and the vegetation is usually very much thinner and poorer than that of the less exposed northern aspects. This effect is clearly seen on Tai Mo Shan. The slopes facing Sek Kong are wooded or have thick vegetation of low scrub, but the southern slopes above Tsuen Wan have a sparse grass cover.

In the case of the granitic areas, excessive insolation on south facing slopes (Plate 5) kills off all but the hardiest grasses, and conditions suitable for erosion are established.

Diurnal range of temperature is usually not more than 10°F and varies little from season to season.

Relative humidity is highest in April with a mean of 85% and it continues at over 80% until the end of August when there is a rapid decrease to a minimum mean of 69% in November.

The crucial temperature in agriculture is that which controls the growing period of rice, i.e. a mean temperature of more than  $62^{\circ}$ . This extends from early March to mid November, thus in the lowland areas two rice crops may be harvested, but in the upland districts only one crop is possible.



## Chapter II

### GEOLOGY

Geological survey of Hong Kong was begun in 1923 but owing to wartime restrictions and the death of all but one of the geologists, the report was not completed until 1948, although the map was published in 1935. In post-war years there has been a considerable expansion of the road network of the Colony, as well as numerous excavations for reservoirs, airfields and buildings. All of these activities have provided a great deal of geological information which was not available to the geologists who made the 1935 map, and the survey is seriously in need of revision, particularly with regard to the mapping of the network of faults, shatter zones and dykes.

The generalised map of the geology (fig. 7) and the geological data on which this chapter is based, have been derived from "The Geology of Hong Kong" by Professor S. G. Davis. A more recent appraisal of the geology of Hong Kong by B. P. Ruxton (Quart. J. Geol. Soc., 1958) was not available in Hong Kong when the soil survey work was being carried out. Discrepancies between the soil evidence and the 1935 Geological map have been noted in the text of this Memoir, and agree substantially with corrections suggested by Mr. Ruxton.



The geological foundation has not unnaturally had a very profound influence on the soils of the Colony, but the relationship is less affected by differences in rock type than by the complex of faults, and mineral breakdown so complete that rocks which may be quite dissimilar in appearance yield almost identical soils. Thus although there are several rock formations in Hong Kong there are only two broad soil distinctions based on geology. Volcanic rocks develop a red soil, which is very different in appearance and characteristics from the yellow and reddish yellow soils which develop on granite. The range of rock types from pegmatite to granodiorite is not reflected in soil differences.

The well defined north-east, south-west structural trend of the south-eastern mountain complex of South China is clearly visible in the distribution and faulting of the rock formation. The oldest rock materials are Permian boulders which occur in the agglomerates of the Tolo Channel sediments, and metamorphosed sediments in the north-east of the Colony. Only a small area of these sedimentary formations remains, having been caught up and dissected by the great regional batholithic intrusions. The dating of the various formations is largely conjectural because only a small number of somewhat indeterminate fossils have been found. The two main batholithic intrusions seem to be associated with the two stages of the Yen Shan orogenic

movements. At the close of the Jurassic period the first Yen Shan earth movement resulted in the intrusion of the Tai Mo Shan porphyries, forming the largest mountains in the Colony. During the Cretaceous period there was a period of erosion and peneplanation, but this was followed by a period of uplift, with consequent rejuvenation of the landscape, associated with the second Yen Shan earth movement. It was during this period of uplift that widespread granitic intrusions occurred. During the Miocene Period there were further volcanic intrusions but they affected only the Eastern peninsulas, and the colony has not been subjected to any further major orogenic movements since that time, although submergence and subsequent emergence have continued until the present day.

#### Tolo Channel Formation

The Tolo Channel formation derives its name from the channel along whose shores it is best exposed. This is the oldest formation recognised in the region and the only one whose age is definitely known from identified fossils.

The rocks of this formation consist of altered volcanics, a series of silicified ash beds, and dense black and gray shales. Quartz veins cut the sediments in places and there must have been intermittent vulcanism as well as serious erosion during the period in which the rocks were

laid down. Most of the pebbles which form the basal conglomerate of the overlying Pat Sin Formation are derived from the Tolo Channel Sediments. Only small outcrops of the Tolo Channel rocks occur, and it is not an important soil-forming formation.

#### Pat Sin Formation

The Pat Sin formation is by far the most widely distributed and most conspicuous of the waterlaid deposits of the Colony. Its thick massive white quartz conglomerate forms sea cliffs along the whole of the north of Tolo Channel, and is the capping material which has preserved the Pat Sin range. A small exposure occurs also on the north west shore of Lantau near Tai O.

Although it is limited in extent the Pat Sin Formation has had a striking influence on topography and land use. For the most part the resistant quartz conglomerate does not break down into an adequate soil for agriculture. There are no trees and only sparse grasses on the sea cliff and mountain top exposures. In the upland plateau of the Sha Tau Kok peninsula the sandstone, argillite and ash beds of the Pat Sin formation weather to form a deep, red soil very similar in appearance, to the Krasnozem of the Tai Mo Shan Porphyries.

### Lok Ma Chau Formation

A series of grey gneissose arkoses, white and cream coloured sandstones, dark argillaceous schists, and white micaceous-talc schists occupy the structural depression which extends in an arc from Castle Peak Bay to the Shum Chun river at Lowu. This formation is believed to be a highly metamorphosed form of the Pat Sin formation, and it seems probable that the rocks were altered and preserved by earth movements associated with the Castle Peak-Shum Chun depression.

Though the Lok Ma Chau Formation is of limited extent it is nevertheless an important soil forming material. Most of the alluvial material in the Deep Bay area is underlain by rocks of the Lok Ma Chau formation, and often these are sufficiently near the surface to affect the soil. The Castle Peak soil association is entirely developed on these rocks. For the most part the soil on this formation is Krasnozem, but at Castle Peak Bay and at other lowlying exposures small areas of Lateritic krasnozem have developed.

### Repulse Bay Volcanics

At the end of the Jurassic period there was considerable volcanic activity in the south of Hong Kong Island, and the resultant Repulse Bay volcanics spread over a large area to the south of the colony. The greater part of Hong Kong Island, the western half of Lantau and the rocky



spine running from Ma On Shan to Kowloon Peak are formed of Repulse Bay volcanics. Almost every type of volcanic product is represented in this formation but the most typical rock is a rhyolite porphyry.

#### Tai Mo Shan Porphyry

Tai Mo Shan occupies the centre of a large area of Tai Mo Shan Porphyry but other outcrops occur over the whole of the North of the New Territories in the centre of Lantau, north Lamma Island, Saikung district and Clearwater Bay. The rock is porphyritic with a grey brown rhyolitic ground-mass and phenocrysts of white feldspar and quartz. Occasionally the phenocrysts are lacking. There are frequent veins of quartz and diabase dykes forming sharp and well defined ridges.

Although the rocks in the formation may be variable in appearance the soils derived from them are a very uniform bright red with a mottled horizon at depths of 30-40 feet. Many exposures of this soil material, which is practically indistinguishable from the soil developed on the volcanic rocks, have well preserved quartz veins, although all other minerals are completely altered and the rock texture destroyed.

#### Tai Po Granodiorite

The main mass of this formation may be seen in the vicinity of Tai Po Market and it has been mapped as occur-



ing in a continuous strip along the south of Kam Tin basin and the Lam Tsun valley as well as in Tsuen Wan, Tsing I and Lamma Island. Granodiorite is not, however as extensively exposed as might appear from the map and is of little importance as a soil parent material. The rock is intermediate to granodiorite and granite and for the most part develops a Red-Yellow Podsollic soil but there is less tendency to form a silica hardpan than in the true granitic soils.

### Granite

The only post Cretaceous rocks of any appreciable extent, with the exception of the Rocky Harbour volcanics and the Mirs Bay sediments, may be broadly classed as granites and are associated with batholithic intrusions of the second Yen Shan earth movement. More than one third of the rock of this area is granite and it is a very important soil parent material. The main granite areas are, the hilly areas on either side of the Castle Peak depression, the hills behind Kowloon and on either side of Tide Cove, and the whole of the northern end of Lantau. Other granite exposures occur in most of the southern islands<sup>s</sup> of the Colony and on Hong Kong<sup>1</sup> Island. The typical rock is coarse grained with an average grain size of about 2mm., the minerals being mainly (a) Quartz, (b) white feldspar (c) slightly pink feldspar and (d) biotite. The granite on the northern end of Lantau, is

porphyritic with large phenocrysts of orthoclase up to 2 cm. in length.

One of the most striking features of granite in this area is the extent, and nature of the weathering which it displays. The physical features of the weathering are discussed more fully in Chapter VIII of this report but some of the chemical changes may be noted in the following table of analyses of Hong Kong Granite by Professor T.C. Phemister of Aberdeen University, and compared with similar analyses by J.B. Harrison of granite katamorphism in British Guiana, (Harrison, 1934).

From the above table it appears that the disintegration of granite in Hong Kong is broadly similar to that in the humid tropical climate of British Guiana, but there are several important differences which should be noted, and which may help in the understanding of some of the soil forming processes on granite in Hong Kong. The most striking feature of the Hong Kong material is the greater breakdown of the  $\text{SiO}_2$  coupled with the greater gain in  $\text{Al}_2\text{O}_3$ . It is probable that the more extreme katamorphism of the local granite may be related to the more extreme rainfall regime of Hong Kong. In British Guiana there is an annual rainfall of 2000 mm. and it is comparatively well spread out through the year, but in Hong Kong although the rainfall is only 2152 mm. it is much more intermittent in occurrence. During the long dry spells between rain showers in Hong Kong the soil is thoroughly baked and the alternation of shaking and desiccation brings

## COMPARISON\* OF KATAMORPHISM OF GRANITE IN HONG KONG

Fresh	Disintegrated		Advanced Weathering		Kaolinised		Texture Destroyed	
	H.K.	B.G.	H.K.	B.G.	H.K.	B.G.	H.K.	B.G.
Quartz &								
SiO <sub>2</sub>	73.37	72.15	72.39	70.17	67.74	66.63	40.47	62.96
Al <sub>2</sub> O <sub>3</sub>	12.85	14.75	15.19	18.84	19.74	21.00	41.30	24.13
Fe <sub>2</sub> O <sub>3</sub>	0.53	2.25	1.07	1.78	2.45	1.55	0.23	1.68
FO	2.37	0.31	1.62	0.25	0.79	0.29		0.36
MgO	0.26	0.70	0.09	0.17	0.09	0.47	-	0.26
CaO	1.15	0.08	-	0.03	-	0.13	-	0.03
Na <sub>2</sub> O	3.26	2.74	0.07	0.21	-	0.27	-	0.11
K <sub>2</sub> O	5.12	4.70	4.29	2.70	0.43	2.75	0.48	1.67
H <sub>2</sub> O	0.35	0.52	4.81	5.17	3.38	6.25	17.81	8.01
CO <sub>2</sub>	0.00	-	0.15	-	0.05	-	-	-
MnO	0.07	0.22	-	-	-	-	-	-
P <sub>2</sub> O <sub>5</sub>	0.04	-	-	-	-	-	-	-
TiO <sub>2</sub>	0.21	0.71	0.14	0.68	0.23	0.61	-	0.75
							11.87	10.32
							-	-
							-	-
							-	-
							-	1.10

\* The weathering zones are not strictly comparative but give some impression of the general trend.

about an extreme breakdown of all minerals, including even the resistant quartz.

### Rock Harbour Volcanics

The rocks of this formation occur only in the Western peninsulas of the Colony and are the most recent of the volcanic rocks. The columnar jointing, in the cliffs and stacks of the west coast of High Island and the Tai Long Wan peninsulas is reminiscent of the quartz porphyry of Drumadoon Point, Arran. These rocks yield a soil similar to those derived from the other local volcanics and porphyries.

The typical rock is a brownish grey rhyolite with phenocrysts of pink feldspar and quartz.

Although they occupy such a large area (more than 12% of the Colony) the Rocky Harbour volcanics play little part in the economy of the region. The rocks are broken up by a network of block faulting, and the terrain is extremely rugged with only a few small coastal patches of cultivation.

### Mir<sup>s</sup> Bay sediments

The Mir<sup>s</sup> Bay sediments provide one of the most interesting formations, although relatively small in extent. These sediments consist of a basal conglomerate, followed by sandstones and shales, all having a bright red colour, which has given rise to the term 'Red Beds'. Similar deposits occur in Szechwan and Thailand. Whether there is any connection between these widely scattered red beds is debatable, but the Hong Kong deposits are almost certainly deltaic



materials, and may be associated with the outfall of an earlier Pearl River.

The soil formed from these rocks has not been studied in detail because it occurs only on small islands in Mir<sup>S</sup> Bay and on the northern slope of Tolo Peninsula from Tolo Crest to Double Haven.

For all normal purposes it may be stated that, as far as hill soils are concerned there are only two soil parent materials in Hong Kong (a) Granite and (b) Other acid igneous rocks. When classifying arable soils, however, it is necessary to be more specific, and geology becomes an important factor. Only granite, Tai Mo Shan Porphyry and Lok Ma Chau metamorphosed sediments have formed appreciable areas of agricultural land.

Most of the agricultural areas are associated with structural depressions and consequently there is a certain similarity of alignment. The largest and most important of these depressions is that extending in an arc from Castle Peak Bay, through Deep Bay, along the Shum Chun River. In its Castle Peak extent the depression lies between parallel faults and has the appearance of a miniature rift valley. Both the Lam Tuen and Sha Tin agricultural areas are obviously fault line valleys, and the settlement of Tung Chung in northern Lantau has arisen at the focal point of

several fault line axes. Only the coastal settlements round the islands and eastern peninsulas seem to be comparatively independent of fault line processes.

A north east southwest trend is reflected in ridges as well as in depressions, and the hills form an effective shield to rainbearing easterly winds, preventing them from providing adequate water for the irrigation of all of the Deep Bay lowlands. There are numerous transverse faults and dykes which affect drainage and communication; these have to follow a stepped or rectangular pattern.

### Chapter III

#### METHODS AND DEFINITIONS

##### Field Methods

Soil survey is primarily a catalogue of the nature, location and extent of the various types of soil in a particular area. The distribution of the soils is recorded on a map and the important characteristics are determined and classified. Soils, in the field, are identified principally by their morphology. When a vertical section of soil is examined in an inspection hole, or a cutting, the material is usually seen to be differentiated into horizons or layers of soil, approximately parallel to the soil surface, and with relatively well developed characteristics produced in the soil forming processes. Such a vertical section through all the soil horizons and extending into the parent material is referred to as the soil profile. The features of the profile which are considered significant in field identification are colour, texture, structure, consistence, organic matter, roots, wetness, stoniness, mottling and thickness of horizons. When these characteristics are studied in inspection pits dug throughout an area it becomes apparent that whilst each profile has individual characteristics certain soils are so alike that

they may be placed in the same primary category. The primary category for mapping is the soil series which comprises soils of similar type and arrangement of horizons, developed on similar parent material.

In nature there are very seldom sharp distinctions between related species, similarly in soil survey the line drawn on the map often implies a merging of soil series and not a sharp change in soil morphology. The soil surveyor makes a systematic inspection of the soils in an area, digging inspection holes to a depth of 2 to 4 feet and noting the profile characteristics. The change from one soil series to another is often gradual but frequently topography and vegetation assist in accurate delimitation of a series.

When the soils are examined in the field it is helpful to use air photographs to assist in noting the exact location of inspection pits and stereoscopic interpretation of air photographs is used to augment the field data when the soil maps are drawn.

#### Cartographic Methods

A map showing soil series is difficult to interpret unless the series are grouped into a significant classification showing their interrelationships particularly with regard to parent materials. In the Soil Survey of Hong Kong it has been found convenient to have separate classifi-



cations for hill soils and agricultural soils. The paddy soils of the agricultural areas are mapped in series grouped into Soil Associations and each Association contains two or more series developed on similar parent material but varying in profile morphology due largely to differences in hydrologic conditions. Such grouping is not very significant in mapping soils of hilly areas where geomorphological situation forms the basis of series differentiation, and the soils are grouped according to the geology of the parent material (Chap. IV).

The Hong Kong paddy soils are very complex and are intensively farmed so that it has been found necessary to publish maps of the agricultural areas on a scale of 1:25,000 (about  $2\frac{1}{2}$  inches to 1 mile) but survey was carried out using air photographs with a scale of approximately 6 inches to 1 mile. Reduction from 6 inches to  $2\frac{1}{2}$  inches introduces certain problems, notably the difficulty of delineating very small areas. Thus it is possible for any uniformly coloured area on the published map to contain within it an area of less than 2 acres in extent of some other series. In practice this seldom occurs. Any locality where there are many different soils would be mapped as a soil complex with the different soil types enumerated in the text. In spite of mapping some areas as soil complexes the map of Hong Kong Agricultural Soils

may appear very complicated but alluvial soils are notably variable and are more so in this area with its confused geology.

#### Description of Soil Profiles

During the survey of an area, sites typical of each soil series are selected and profile pits dug. These pits are dug to a depth of 4 or 5 feet and are large enough to allow the soil surveyor to take samples at precise depths and to make a careful examination of the soil profile. Each soil horizon is described in detail and the profile description, in conjunction with analyses of soil samples, forms the basis of interpretation of the soil forming processes.

In the paddy and vegetable growing areas it is seldom possible to dig profile pits except in the winter. During the growing season the land is under water or crop almost continuously. The soil as it appears dried out in the winter may have very different properties from the submerged soil in which rice grows. To offset this, wherever possible duplicate profile pits have been dug, one in winter and the other in the one or two days between harvest of the first crop and transplanting of the second. Soil changes resultant on alternate submerging and drying out must be carefully borne in mind both when describing the

profile and in analysing the samples.

### Laboratory Investigations

Each horizon and sometimes each subdivision of an horizon is sampled. The soil samples are taken to the Agriculture, Fisheries and Forestry Laboratory in Kowloon and each is given a thorough, routine physico-chemical examination. This Laboratory has only recently been established and has been built up in the course of soil survey. Though the laboratory is well equipped to tackle most of the usual soil analyses, there has been insufficient time to deal with all the samples as exhaustively as might be wished. The analyses carried out are shown in Appendix I.

Some profiles have been selected and sent to Scotland for analysis by the Macaulay Institute for Soil Research.

Certain of the samples, particularly from hilly and eroded areas, have been selected for analysis by mineralogical, differential thermal, spectrochemical and X-ray methods either at the Macaulay Institute or at Rothamstead Experimental Station in England.

### STANDARD TERMS AND DEFINITIONS

Soil profiles are described in standard terms so that the descriptions may be strictly comparable, not only one with another in Hong Kong, but also with soils elsewhere.

Though in general these terms used in the Hong Kong survey follow standard British and American usage, some Japanese suggestions on horizon nomenclature and certain Russian ideas on World Soil Groups have been adopted. In addition it has been necessary to use certain terms and ideas which have special relevance to Hong Kong, but as far as possible international practice has been followed.

The standard terms and symbols used to describe the site and the soil profile are defined below. Of the characteristics which apply to the site, namely Relief and Slope Class, Land Utilisation, Aspect, Altitude, and Vegetation, only the first two are treated here the others being self explanatory.

Drainage class, <sup>q</sup>Geomorphological situation, and Horizon nomenclature which involve the whole profile are considered next and finally the properties of the individual horizons: Colour, Texture, Structure, Induration, Amount of Organic Matter, Stoniness, Mottling and roots.

### Relief and Slope class

The soil map shows contours at 10 metre intervals which gives a comprehensive picture of the relief but often it is the microrelief which is of importance in determining<sup>ing</sup> the variations in soil series. Some aspects of the micro-



relief are explained in the section on Geomorphological situation but it is also useful to relate soil series to slope. To facilitate this, single slope classes are defined and based on convention used by the U.S. Soil Survey (Soil Survey Staff, 1951).

<u>Class A</u>	Name:-level	<u>Class D</u>	Name:- Moderately steep
Lower limits 0%		Lower limit 10-16%	
Upper limit 1-3%		Upper limit 20-30%	
<u>Class B</u>	Name:-gentle	<u>Class E</u>	Name:-steep
Lower Limits 1-3%		Lower limit 20-30%	
Upper Limit 5-8%		Upper limit 45-65%	
<u>Class C</u>	Name:- mode- rate	<u>Class F</u>	Name:-very steep
Lower limit 5-8%		Lower limit 45-65%	
Upper limit 10-16%		Upper limit - None	

#### Land Utilisation

In Hong Kong it has been found to be fairly simple and very useful, when surveying rice soils, to make an assessment of the yield of rice and to note the cropping pattern.

Most of the rice soils may be surveyed only in the winter but the rice stubble is a very accurate indicator of the yield. With practice, a soil surveyor in this

restricted area can make an estimate which is accurate to within 150 lbs. The local farmers calculate both rice yield and rent for land in terms of catties or piculs per dau chung and these weights and measures are used throughout this memoir.

Yield in Catties/Dau Chung (fresh water rice)	Equivalent in lbs./acre	Land Assess- ment
150	1000	poor
150 - 250	1000 - 1650	fair
250 - 400	1650 - 2640	good
400	2640	very good

There are normally two crops of rice per year obtained from the agricultural land in this area. In the brackish water areas round Deep Bay only one crop can be grown in a year and though the yield may be high (400 catties/d.c.) the quality is inferior and the land is assessed as poor.

If vegetables are grown in the rice field in the winter, the rice yield is greater owing to the effect of residual fertiliser.

Obviously the yield must only be assessed in conjunction with the cropping pattern. The normal patterns are listed below.

1 crop brackish water paddy.

2 crops fresh water paddy.

2 crops fresh water paddy plus winter vegetables.

Vegetables all year.

There may be variations of these four categories but for most purposes this classification is sufficient.

#### Drainage Class

The word drainage has many meanings but here it refers strictly to the morphology of soil profiles. In this memoir only the agricultural soils have been classified on drainage. For all practical purposes the agricultural soils may be described as rice soils though in postwar years vegetables have been intensively grown in some areas. The drainage characteristics of rice soils are described in Chapter IV.

#### Geomorphological Situation

In all of the soils in Hong Kong it has been found invaluable to make a careful assessment of the geomorphological class of each profile site. The term Geomorphological Situation is used purposely instead of the more usual 'land-form class' to emphasise the need for preciseness. Words such as hilltop, plateau, and alluvium are comparatively

unhelpful in describing the particular landform on which a soil profile is developed. The terms as they are used in the Hong Kong Survey may be explained diagrammatically in figure 9 and are defined as follows:-

**Skeletal:--** This term is used to describe areas in which the bare parent rock appears at the surface and the soils are very thin. Such soils are formed primarily by physical rather than chemical weathering.

**In situ:--** On the flatter upland areas the soils are very deep and are almost entirely developed by chemical weathering. There has been no lateral translocation of the soil and all the material rests where it has been formed.

**Colluvial:--** Areas which have been built up by the material which has slipped, slumped or slid, down the hillsides are described as colluvial.

**Boulder  
Fan:--**

When a mountain torrent debouches on a plain the sudden decrease in velocity of the stream causes it to shed its load of material and a cone or fan is built up.



In many cases in Hong Kong these fans are largely composed of large boulders.

Alluvial  
Fan:--

The streams from the lower mountains in Hong Kong do not bring down such heavy loads of stones. If the cone of deposition is composed of less than 30% stones and gravel it is described as an alluvial fan.

In referring to alluvial deposits, wherever possible the term alluvium is qualified to describe the particular mode of formation e.g. lacustrine, marine, or lagoonal, but where the material is of recent stream origin it is classified as undifferentiated.

Horizon Nomenclature

One of the most useful conventions in soil survey is the use of symbols in referring to soil horizons. The symbols normally used are A, B, C, D AND G. General definitions of the layers or horizons to which these symbols are assigned is given first, followed by more precise definitions applicable to the major soil groups which occur in Hong Kong.

The A horizon is the upper mineral part of the solum, and is the horizon of maximum biological activity. The

subhorizons are named and described in the following paragraphs.

- A<sub>1</sub> Horizon: This is a surface mineral soil horizon, usually dark in colour and with a relatively high content of organic matter. In most Hong Kong soils the A<sub>1</sub> horizon is quite thin.
- A<sub>2</sub> Horizon: This surface or subsurface horizon, is usually lighter in colour than the A<sub>1</sub> or A<sub>3</sub> and has been leached of its iron, aluminium or clay minerals.
- A<sub>p</sub> Horizon: This is a ploughed or otherwise mixed surface horizon. The subscript p indicates disturbance by cultivation.
- A<sub>pg</sub> Horizon: The subscript g indicates gleying such as occurs in the surface horizons of paddy soils.

The B horizon of a soil is a master horizon of altered material characterised by accumulation of material washed down from the A horizon and by having a bright colour and a more or less blocky or prismatic structure. The C horizon is the term descriptive of the weathering rock or other parent material from which the soil has developed. In Hong Kong, particularly in the granite soils the C

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The D Horizon is the consolidated parent rock from which the C. Horizon has developed, or like that from which the parent material of the solum has developed if no C Horizon is present.

Horizon is often many feet thick, preserving the appearance of solid rock but crumbling to the touch.

The G Horizon is a layer of intense reduction characterised by bluish gray or gray colours and the presence of <sup>e</sup>ferrous iron. It has been found advisable to follow the arrangement devised by Kanno\* in distinguishing horizons with blue gray colour due to reduced iron compounds from horizons produced by oxidised iron and manganese compounds. The capital G is applied to descriptions of horizons or 'spots' whose colour is due to reduction gleying and the small g is reserved for use in description of horizons coloured with mottles of ferric and manganese compounds.

Horizon nomenclature as applied to the Major Soil Groups represented in Hong Kong is shown diagrammatically in figures 11 and 12.

### Colour

Though the colour of soil horizons may be deceptive as a criterion in assessing rice soils, for most practical purposes soil is classified on its morphology or appearance, and colour is naturally an important factor. To ensure uniformity in describing soil colour accurately and con-

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\* I.Kanno. Soil and Plant Food Vol.2, No.3, 148-157 (1957).

cisely the Munsell Soil Colour Charts have been used by the Hong Kong Soil Survey.

According to the Munsell system, each colour can be considered as the resultant of three variables, Hue, Value and Chroma, and each is designated in that order, for example (10YR 3/2). The Hue is 10YR, the Value is 3 and the Chroma is 2. Moreover each colour is given a standard name so that 10YR 3/2 is very dark gray brown.

A dry soil sample frequently has a different colour from a moist sample and it is usual to note whether the Munsell notation refers to a wet or dry soil. In Hong Kong almost all the samples have been described in a moist condition, but exceptionally when the soil is greatly altered in colour by drying, both wet and dry Munsell Notations are given.

### Texture

Perhaps the most useful skill a pedologist can develop, is the ability to assess by touch, the relative proportions of the various size groups of primary particles in the soil. A moistened sample of soil is rolled between the thumb and forefinger and it is possible to gauge the amount of sand, silt or clay in the sample. Field Texture assessed in this way is a very useful comparison with the Laboratory texture which is the separation of soil



fractions by mechanical analysis. The limits of the separates follow the U.S.Dept. of Agriculture scheme and are defined below.

Name of Separate		Diameter (mm)
sand	{ very coarse sand	2 - 1
	{ coarse sand	1 - 0.5
	{ medium sand	0.5 - 0.25
	{ fine sand	0.25 - 0.1
	{ very fine sand	0.1 - 0.05
	silt	0.05 - 0.002
	clay	less than 0.002

### Textural Class

In naming the textural classes of soils, the Hong Kong Soil Survey has combined all the sand separates into one, with the general name -- sand. The percentage of each separate of a sample is plotted on a triangular diagram (fig. 8), and the soil is assigned the textural class name appropriate to its position in the triangle.

### Structure

In some soils such as those formed on sand dunes each soil particle is loose and easily separated from its neighbours, but in other soils such as clays it may be difficult to separate the primary particles and distinctly

shaped peds or aggregates are formed. The grouping of the primary particles of a soil into compound units is described as its structure and is an important characteristic.

Soils are described as having a poor structure if the aggregates are of such a nature that they render the soil unproductive or difficult to work, e.g. in some salty soils the structure is markedly columnar but as soon as the soil is wetted it becomes shapeless and the drainage is very seriously impaired. Where the structure is an aid to agriculture it may be described as good, e.g. the medium to fine crumb structure often found in the few long-established forested areas in Hong Kong, is a very desirable feature.

There are four primary types of Structure:

1. Platy - With one dimension, the vertical, greatly less than the other two. Platy structure is often found in the top few mm. of paddy soils.
2. Prismlike - With the vertical dimension much greater than the other two dimensions. Freely drained granitic soils in Hong Kong frequently have prismatic structure.
3. Blocklike - With three dimensions of the same order of magnitude but having plane

or curved faces that are casts or moulds of adjacent peds.

4. Spheroidal - With three dimensions of the same order of magnitude having plane or curved faces with little or no accommodation to the faces of surrounding peds.

Relationships between the various classes and types of structure is given in table A. (p. 43).

When the soil horizon shows no compound units it is termed structureless, and can be either single grain (if non-coherent) or massive (if coherent).

Grade of structure is the degree of aggregation and expresses the differential between cohesion within the aggregates, and adhesion between the aggregates, and is determined according to the following definitions.

1. Weak - aggregates barely visible in situ.  
When disturbed the soil material breaks into a mixture of a few unbroken and many broken units with much unaggregated material.
2. Moderate - Well formed units but not distinct in undisturbed soil. When disturbed there are many distinct units, some broken units and some unaggregated material.

3. Strong - Well formed units, distinct in undisturbed soil, adhering only weakly to one another.

### Induration

The induration of a soil material refers to a handling property of soil which appears not to be markedly affected by moisture content. Induration is particularly noticeable in paddy soils and also occurs in certain of the Red-Yellow Podsollic profiles in Hong Kong. Three terms are used to describe this property and they are defined below.

1. Weakly indurated -- not usually detected when digging but presence shown by stabbing a knife in profile face. Breaks easily in the hand.
2. Moderately indurated -- noticeable when digging. Breaks in the hand under moderate pressure.
3. Strongly indurated -- so hard as to cause difficulty in digging. Not readily broken in the hand.



### Organic Matter

The soils of Hong Kong are generally lacking in organic matter; there are no surface peat soils and there are very few soils with more than 8 - 10% humus. Accordingly the terms used here to describe the amount of organic matter are relative and could not be applied to temperate soils. The limits of standard terms as they are applied to Hong Kong soils are defined below.

High	-----	over 8%
Moderate	-----	5% - 8%
Low	-----	under 5%

### Stoniness

Stoniness is an important property of a soil. Stones dilute the finer material and normally increase the permeability of the soil, thus they are frequently desirable elements in paddy soils.

The terms used in describing the stoniness of soil horizons are not precise; they are defined below.

few stones	-----	15% by volume
stony	-----	15 - 50% by volume
very stony	-----	50% by volume

### Mottling

The rusty, black or grey spots that occur in soils

of impeded drainage, are described as mottles and their nature, distribution and colour is an indication of the drainage status of the soil. Both iron and manganese are involved in the formation of mottles and it is of particular importance in rice soil classification that the relative proportions of iron and manganese in each horizon should be carefully assessed and that the mottling due to oxidation should be distinguished from that caused by reduction.

Mottles due to oxidation in paddy soils may be divided into four kinds on the basis of colour, namely, (a) brownish black 5YR2/1, 2/2 (b) dark brown (10YR 2/2) (c) reddish brown (10YR 4/4) and (d) reddish yellow or ochre (10YR 7/8 or 10YR 6/8). In general the first two kinds of mottles contain much more manganese than do the last two.

The size, frequency, and contrast of mottles is assessed on the following scales.

few - mottles 2% of surface

frequent - mottles 2-20% of surface

abundant - mottles 20% of surface

fine - 5mm.

medium - 5-15mm.

coarse - 15mm.

faint - hue and Chroma of matrix closely related.

TABLE A

TYPES AND CLASSES OF SOIL STRUCTURE

CLASS (size)	TYPE Shape and arrangement of peds					
	PLATELIKE	PRISMLIKE		BLOCKLIKE	SPHEROIDAL	
		Without rounded caps	With rounded caps		Relatively Non Porous Peds	Relatively Porous Peds
	Platy	Prismatic	Columnar	(Angular)Blocky	Subangular Blocky (rounded)	Crumb
very fine	very fine platy 1 mm.	very fine prismatic 10 mm.	very fine columnar 10 mm.	very fine blocky 5 mm.	very fine subangular blocky 5 mm.	very fine crumb 1 mm.
fine	fine platy 1-2 mm.	fine prismatic 10-20 mm.	fine columnar 10-20 mm.	fine blocky 5-10 mm.	fine subangular blocky 5-10 mm.	fine crumb 1-2 mm.
medium	medium platy 2-5 mm.	medium prismatic 20-50 mm.	medium columnar 20-50 mm.	medium blocky 10-20 mm.	medium subangular blocky 10-20 mm.	medium crumb 2-5 mm.
coarse	coarse platy 5-10 mm.	coarse prismatic 50-100 mm.	coarse columnar 50-100 mm.	coarse blocky 20-50 mm.	coarse subangular blocky 20-50 mm.	
very coarse	very coarse platy 10 mm.	very coarse prismatic 100 mm.	very coarse columnar 100 mm.	very coarse blocky 50 mm.	very coarse subangular blocky 50 mm.	very coarse granular 10 mm.

distinct - matrix and mottles vary 1-2 hues and  
several units in chroma and value.

prominent - matrix and mottles vary several units in  
hue value and chroma.

Mottling is also a feature of most tropical soils of deep chemical weathering, but in many cases the cause cannot be attributed to simple oxidation and reduction of iron and manganese. In such cases (e.g. in the Krasnozem, Red Yellow Podsollic and lateritic soils of Hong Kong) the same terms are used as for ochreous and other mottles but it is even more important that the colours should be quoted in reference to the Munsell scheme.

### Erosion

Various terms are used in describing different types of erosion and the different shapes of gullies but these terms are fully explained in the section dealing with eroded soils.



## Chapter IV

### SOIL FORMATION AND CLASSIFICATION

Soil may be defined as "the collection of mineral and/or organic material, occupying portions of the earth's surface, that supports plant life and that has properties derived from the integrated effect of climate and living matter acting on parent material, as conditioned by relief, over periods of time". The characteristics of the soil at any one place are the result of the interaction of five genetic factors, climate, parent material, relief, vegetation and time, but often the soil development is also modified by agricultural methods. In practice, however, all the genetic factors are not equally important in determining the nature of profile development in every soil. Soil classifications used in Hong Kong are based on the most important characteristics from a land utilisation point of view but it is useful to relate Hong Kong soils to other tropical soils. To appreciate these relationships it is necessary <sup>to</sup> study the causal environmental factors.

#### Factors affecting the distribution of Major Soil Groups.

By correlation, the pedologist is able to draw general conclusions concerning soil genesis and the effect of each soil factor. In a normal location, however, there

are usually differences in more than one genetic factor, and the influence of each is either diminished or enhanced by interaction with the others.

### The Climatic factor

Climate influences soil formation mainly through the moisture and energy that it gives to the environment. Within limits the organic matter content of a soil increases as the precipitation increases and as the temperature falls. This relationship has a very important bearing on the distribution of Major Soil groups in Hong Kong. From the rainfall map (fig. 6) it will be noted that the rainfall is greatest along the spine of Lantau, on Tai Mo Shan and in the Eastern Peninsulas. In addition, these three mountainous areas are often swathed in cloud and the temperatures there are lowered both by altitude and by reduced insolation. One result of these climatic differences has been the development of soils which are markedly podzolic in appearance. Thus at the top of Tai Mo Shan the soils may be classed as Red-Yellow Podsollic, while the same parent material below 1,500 feet develops a strikingly different profile and may be classified as Krasnozem. At still lower altitudes where residual soils have developed on Tai Mo Shan Porphyries, at sea level to about 500 feet, there is a marked tendency for Lateritic Krasnozem to form.

On the very steep slopes at high altitudes in the regions of high rainfall there is frequently no evidence of humus accumulation or differentiation in the mineral solum, erosion keeping pace with <sup>thee ?</sup> ~~this~~ soil forming processes, <sup>I</sup> Thus lithosols are formed.

### The Parent Material factor

The soil parent material consists of the geological deposits and formations upon which the soil forming processes act. Parent Material exercises a dominating influence on the distribution of the Major Soil groups in this area, its most influential property being texture.

The textural differences of the soil parent materials are related to the parent rock and to the degree of chemical and physical weathering. Where the parent rock is coarse grained and particularly with large quartz crystals (e.g. granite), the weathered material is generally open textured whether formed in situ or transported. In the case of cryptocrystalline or fine grained rocks, such as some of the volcanics and porphyries in Hong Kong, a very compact dense soil develops in situ, but where the material suffers transportation as colluvium or in streams, the soil develops a more permeable structure.

Soil-water relations are closely allied to texture of the parent materials, and the coarse texture of

weathered granite favours development of podsollic features even at sea level. In such coarse textured parent materials small variations in texture have little effect on soil hydrology, and the Paddy soils developed on such deposits are all so similar that they are grouped into one (Shatin) Association.

Small variations in texture within the range moderately fine to fine have a marked effect on land utilisation, drainage and handling properties. One indication of the effect of these variations is the comparatively large number of Associations that are formed on soils derived from Tai Mo Shan porphyry material.

Many of the rocks in Hong Kong are very rich in iron, and while this does not influence the distribution of Major Soil Groups, it has had considerable influence in the profile morphology within a Group. Leaching of iron from the upper horizons and formation of a weak iron pan in the lower horizon has brought about conditions resulting in serious erosion in some granitic soils, notably in the Castle Peak and Tai Lam Chung areas.

Ferruginous content of soil parent material is also noted in the paddy soils. Coarse textured permeable soils may be induced to yield economic quantities of rice when a firm iron pan is developed to maintain a surface flooding, thus rice is grown on dune soils (notably in South Lantau



at Cheung Sha). On the other hand soils with a silty texture more favourable for rice production, may not be worth planting to rice in their freely drained series because surface flooding cannot be maintained.

### The Relief factor

Hong Kong might almost serve as a textbook illustration of the influence of relief on soil genesis though it is frequently difficult to disentangle relief as a factor from all the other factors such as geology, vegetation, and climate.

There is, however, a distinct relation between relief and thickness of weathered material. Granite, for instance, is often weathered to a depth of over 100' below surface, but where the granite presents a steep slope, the rock is bare at the surface and is less affected by intense chemical weathering than by physical processes, consequently lithosols are developed.

Very low relief is equally important with steep slopes in controlling soil forming processes. The extensive area of swampland round Deep Bay arises from deposition of alluvial materials in a shallow basin and there is insufficient slope for adequate drainage. Solonchak soils have been extensively formed. Every year the farmers

have to wait until the rainy season for sufficient salt to be washed out of the soil to permit cultivation.

The Vegetation factor.

In the saline mud flats round Deep Bay there are large areas under seagrass and a low scrubby form of mangrove. The decaying litter from these shrubs and grasses helps to impart an inky blackness to the soils. Throughout the alluvial areas of the Colony, particularly in the Fanling district, there are patches of soil which show the characteristic black colour, derived from mangrove swamp (Fanling Association), though the saline effect is no longer visible.

In Hong Kong as a whole vegetation is not a very reliable guide to soil changes except in so far as there is a notable difference between the closeness of vegetation cover on volcanic areas and the thinner cover on granitic soils.

Most of the deep in situ soils, both in granitic and volcanic areas show signs of deeper root penetration than occurs with the present grassland vegetation. In profiles dug on Grassy Hill, Tai Lam Chung and on Tai Yu Shan, there have been distinct traces of tree roots. It is probable that, at least in some of the hilly areas, the natural climax vegetation would be forest or thick scrub

rather than grassland. In the section on "Vegetation, Erosion and Afforestation" (Chapter VIII), the consequences of this hypothesis are discussed in detail, but it may be noted here that clearing forest cover from steep mountainous areas such as Tai Mo Shan and Tai Yu Shan would undoubtedly account for many of the erosional and depositional features of the present soils of Hong Kong.

#### Time Factor

Time is not a prime criterion in genesis of Hong Kong soils, though there are some interesting soils with indurated pisolitic laterite in buried horizons, (Castle Peak B Association in Sek Kong Valley) showing that in a previous soil cycle there was a different environment.

#### The Human Factor

Man's activities in this area have profoundly altered the soils. Cultivation of paddy has imposed a particular profile on several different types of alluvial, residual, and colluvial material. The wet paddy soil profile is very distinctive and its features are discussed in detail in a separate section.

Human activities have also influenced the soil on the hills, and much of the erosion in the Tai Lam Chung and Castle Peak areas can be directly attributed to



deforestation, grasscutting, grass burning, and foot paths. In addition, the grasscutting and frequent burning of vegetation by grasscutters has prevented the development of vegetation and accumulation of humus. Soils therefore develop with poor cohesion in their surface horizons and an insufficient protective cover of grass. Where the slope is insufficient to cause loss of topsoil by gully erosion, the alternate soaking and baking of the bare earth results in formation of a "mud pie" crust and the finer soil particles are carried away by the wind.

Therefore, although climate, relief, parent material, vegetation and time are the primary factors of soil development, human activities have modified almost all of the soils in the Colony.

#### B. WORLD SOIL GROUPS IN HONG KONG

The soils of Hong Kong have been referred to as lateritic.\* There can be little doubt that many of the processes involved in laterite formation are operative here but the term lateritic used without qualification may be

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\* Davis S.G. (1949) Hong Kong in its Geographic setting. London, Collins.

(1952) The Geology of Hong Kong. Hong Kong, Government Printer.

Tregar T.R. (1958) Land Use in Hong Kong & the New Territories. H.K. University Press.



very misleading. True lateritic soils have been described as red tropical soils with a silica to alumina ratio of 1.3 to 1.0 or less. Hong Kong soils seldom have a ratio of less than 2.0 and are often more. There is a temptation to describe any brick red tropical soil as lateritic, perhaps adding an adjective to account for some other characteristic of the soil. However as Pendleton and Prescott (1952) point out, the concept of laterite as a brickstone has been obscured by the association of the term with the brick red colour. The essential feature of laterite, as originally described by Buchanan (1807), is not its colour but its brick like induration which results from exposure of the reticulated mottled zone to the air. Kellogg (1949) has suggested that the term laterite be confined to those ferruginous materials which harden on exposure, and to the relics of such materials. The induration may be either a concretionary or a cellular mottled hardpan or crust. Such phenomena do occur in Hong Kong but almost exclusively in fossil form, and the greater part of the red soils of this area may be more properly classified as Krasnozem (Gerasimov 1958) and Red-Yellow Podsollic. In general the granitic rocks give a Red-Yellow Podsollic soil at all altitudes but the volcanic rocks develop Krasnozem below 300 m. and Red-Yellow Podsollic at greater altitudes.

For comparative purposes and because pisolitic ironstone does occur in limited quantities, the features of Laterite are given among descriptions of the other Great Soil Groups of Hong Kong but it should be emphasised that the occurrences are more in the nature of curiosities rather than deposits of agricultural or commercial significance.

LATERITE:

Characteristics: True laterite as described by Prescott & Pendleton (1952), is a massive concretionary or vesicular ironstone formation originally formed on areas of low relief subject to high water tables.

In the complete laterite profile there are four main horizons. At the top is a deep red ferruginous zone which may form the ironstone crust or cuirasse. Below the crust is a mottled zone of white kaolinitic material with red patches. Downwards the ferruginous mottlings become fewer and a whitish layer or pallid zone is reached. The pallid zone merges gradually into the parent rock. Such a profile has never been found in Hong Kong. Many soils occur with mottled and pallid zones but not associated with ironstone to any great extent.

The iron cemented crust may take several forms, but in Hong Kong only the conglomerate and the concretionary types occur.

Genesis:

Laterite is formed by the leaching out and elimination of  $\text{SiO}_2$ , alkali, and alkaline earths, and the accumulation of iron and aluminium oxides in their hydrated forms. Concentration of sesquioxides may arise either through enrichment or through withdrawal of non-sesquioxides. Both of the Hong Kong types of ferruginous accumulation are due to enrichment by sesquioxide charged water.

Occurrence:

Small concretions of iron and iron coated quartz occur in low lying residual soils of the San Hui district, Castle Peak and in the Fanling plain. The concretions are normally  $\frac{1}{4}$  inch to  $\frac{1}{2}$  inch in diameter and are found either on the surface or at about 10 inches depth. Lateritic conglomerate or Gallery Laterite (D'Hoore, 1954) is present in bouldery detrital material in the Sek Kong Valley. The lateritic material lies mostly at depths of 4 to 10 feet below subsequently deposited alluvial material, though iron

cemented conglomerate boulders washed down by streams are occasionally found throughout the Sek Kong-Kam Tin area.

**Utilisation:** The gallery laterite does not directly affect agriculture but the concretionary form occurs in soils that are suitable for Pine trees. Fruit trees grown on soils containing concretionary material (Castle Peak Agricultural Station) appear to suffer from trace element deficiencies, as judged from leaf symptoms.

**KRASNOZEM (Red Loam, Rotlehm):**

**Characteristics:** Krasnozems are characterised by lack of profile development. There is a thin humus deficient A horizon on a very deep friable clay loam (B)C Horizon. In many road cuttings in Hong Kong the (B)C Horizon extends to more than 40 feet of depth with no visible variation. The soil has a granular, angular blocky structure and a friable character, but in positions of imperfect drainage there is a strong tendency for silting up and formation of a badly aerated soil structure. In Hong Kong there appear to be two variations of Krasnozem. (a) the very deep, very



friable soil corresponding exactly to the Australian description of Krasnozems (Stephens, 1956) and (b) a less deep, less friable soil which exhibits strong swelling when wet and develops numerous shrinkage fissures on drying, or breaks down into small sharp edged aggregates. This latter form is more closely identified with the description of Krasnozems given by Kubiena (1953). Distinction between these two forms is not practicable in Hong Kong and is probably associated with drainage and depth of weathering.

Genesis:

These soils lack significant profile development because of the flocculating effect of their high content of hydrated ferric oxide which minimises movement of their generally kaolinitic clay by normal eluvial processes. Krasnozems occur under generally humid conditions and in the humid tropical climate of Hong Kong they are found on all but the most siliceous rocks, weathering rate being fast enough to release sufficient hydrated ferric oxide to maintain flocculation (Colwell, 1958).

**Distribution:** Krasnozem is the most widespread of Hong Kong soils. All rocks except granite develop these red or purplish red deposits but at altitudes of greater than 1,500 feet the podsollic influence is dominant.

**Utilisation:** Because of their friable nature and initial high fertility these soils are favoured for a wide range of agricultural crops and forestry but the fertility is deceptive and many fruit trees fail to progress after four or five years normal growth. Sugar cane and Pine trees do well on Krasnozem.

**Analogues:**

It has not been possible to obtain copies of the new soil map of the Chinese People's Republic on a scale of 1:4,000,000 (Ma Yun-Chihi, 1957) but from a very much reduced map (1:20,000,000) in Pochvovedeniye (1958) it would appear that Gerasimov and Ma place the Hong Kong area just within the "laterite and lateritic" soil region, but penetrated by outliers of "Mountain Krasnozem and Zheltozem". Unfortunately neither Gerasimov nor Ma gives any examples of profiles or analytical data of these soils in China.

In the Szechuan Red Basin (1944, 1945) profiles have been described (Tankuanyao series, Sinshan series) which are in most respects exactly comparable with soils designated as Krasnozem in Hong Kong. Gerasimov and Polynov are referred to in an article on the Agricultural soil regions of Szechuan (Hou; Chang; Tseng, 1956) as being of the opinion these red earths or krasnozems in the Red Basin are fossil soils from which the podsollic or lateritic upper horizons have been removed by erosion. Such truncation is entirely in accord with Hong Kong geomorphology (Chap. VIII) and it is possible that soils classified as Krasnozem in Hong Kong could be more correctly described as beheaded podsollic soils.

In his account of the soils of South China, Gerasimov (1958) has pointed out that "all the lateritic fossils and laterites are podsolised to some degree" but "they are almost always beheaded and for this reason have no clear characteristics of podsolisation. Thus, field observation has shown that two processes are of principal importance; deep decomposition (illimerisation) of the soil mass, and podsolisation developing in the upper soil layer".

The soil described as Black-Red Latosol by Kellogg (1949), in the Belgium<sup>an</sup> Congo is in many ways analogous to the Krasnozems of Hong Kong but the reds of the sol~~olum~~<sup>olum</sup> trend to be darker in the Congo soils.

LATERITIC KRASNOZEM:

**Characteristics:** This soil is essentially the same as the non-lateritic Krasnozems but with a Horizon of Laterite at various depths in the profile. The lateritic horizon is seldom thick and is often fragmentary or diffuse, merging gradually into the underlying mottled and pallid zones beneath. Most often the indurated layer appears at the surface when there has been sheet erosion brought on by lack of vegetation. It should be noted that there is very seldom any gully erosion in this soil.

**Genesis:** These Lateritic Krasnozems seem to be in close relationship with the more compact, less freely drained soils mentioned in the description of Krasnozems and it is likely that they arise through accumulation of sesquioxides in a zone of impeded drainage, being encouraged by alternate wetting and drying.

**Distribution:** Small areas of Lateritic Krasnozems mingle with normal Krasnozems in the more lowlying areas of volcanic rock, notably at Castle Peak, Chau Pang Nai and Ta Kwu Ling.



Utilisation: Lateritic Krasnozems is less favourable to agriculture than the non lateritic variety but the areas of occurrence are small and there appears to be little difference in response of trees on the two soils.

RED-YELLOW PODSOLIC:

Characteristics: Red-Yellow Podsolc soils as described by the Soil Survey Staff U.S.D.A. (1948), are "a group of well developed acid soils having thin organic  $A_0$  and organo-mineral  $A_1$  horizons over a light coloured bleached  $A_2$  horizon over a red, yellowish red or yellow more clayey horizon. Parent materials are all more or less siliceous. Coarse reticulate streaks or mottles of red, yellow, brown or light gray are characteristic of deeper horizons where parent materials are thick". Where the vegetation cover is very thin the  $A_0$  and  $A_1$  horizons may be washed off and the  $B_1$  and  $B_2$  horizons may be exposed to severe drying out conditions. Large vertical cracks, pores, and root channels appear and a prismatic structure develops. These cracks are lined with a strongly marked clay skin. When rain

gets into the cracks, the soil swells and the prismatic blocks may be displaced exposing the subsoil to gully erosion. This type of erosion seldom occurs on soils other than granitic and it is hoped that study of the clay mineralogy may supply the reason. It would appear likely that Kaolinite clay minerals predominate in the granitic soils while the other Red-Yellow Podsollic soils in the cooler, higher altitudes in Hong Kong, may have a higher proportion of hydrous mica clays.

Genesis:

Various theories on the genesis of Red-Yellow Podsollic soils have been put forward and rejected in recent years, but no theory yet established seems to account for all the phenomena observed in this Soil Group.

Red-Yellow Podsollic soils have developed under intense weathering conditions in humid tropical climates. The first stage seems to involve the alteration of easily weatherable minerals to secondary clays. As the bases are lost, insoluble oxides are segregated as amorphous materials. Clays are concurrently

formed in situ (McCaleb, 1959).

The prismatic blocks of the B<sub>2</sub> horizon are not cemented by organic matter or sesquioxides for they are predominantly light yellow or greyish in colour and the pH is generally lower than elsewhere in the profile so iron and aluminium should not have been precipitated. The heavy showers of the summer may cause hydrolysis of silicates, but baking heat immediately following the rain, results in solutions containing SiO<sub>2</sub> being drawn to the surface to form a coating on the soil grains (Winters, 1942).

**Occurrence:** Red Yellow Podsollic soils occur on the granitic soils of the Colony at all heights and at altitudes of greater than 1300 feet in the volcanic soils.

**Utilisation:** The soil normally carries a cover of grass or thick scrub but where this cover is grazed or burnt off, the organic horizons are washed off, silicate crusting occurs and, in granitic areas, erosion follows. However Pine (Massoniana) and Casuarina (Equisetifolia) which are not heavy feeders can readily be

established on this generally open textured, freely drained soil.

Analogues:

Professor Thorp who wrote the "Geography of the Soils of China" (1936) has correlated the podsollic soils of south-eastern China with the Red-Yellow Podsollic soils of the United States. In a more recent publication (Report on a field study of Soils of Australia, 1957) Thorp has drawn attention to certain features which occur in soils classified as Red-Yellow Podsollic, in Australia and in the United States. Many of these features are common in Hong Kong.

In the humid and sub humid regions of Australia and in many parts of Texas there is evidence of mass movement of both soil and parent material from upper to lower slopes. "Stone lines" may occur both at the contact of soils with the underlying rock and at the contact of A horizons and B horizons. In Hong Kong soils "stone lines" are well developed in most of the podsollic profiles and play a part in the erosion of some of the granite areas (Chap. VIII and fig. 32).

The Yellow and Red Podsollic soils of the south-eastern United States generally are dominated by kaolinite and sesquioxides in their B horizons. The content of



illite and mont<sup>m</sup>morillonite generally is low, and the / exchange capacity for cations is low. Clay mineral analysis of a representative selection of Hong Kong soils has shown that kaolinite is markedly dominant and gibbsite occurs <sup>in</sup> only minute traces.

One of the most important features of Hong Kong Red-Yellow Podsollic soils is the frequent occurrence of a hardpan or indurated layer at depths of 10-12" in some soils, but more frequently, at the surface of "beheaded" profiles. Fragipan is not an essential feature of Red-Yellow Podsollic soil but such structures have been noted by Winters (1942) in Kentucky, and are common in Queensland.

Recent Chinese (Academica Sinica, 1956) and Russian (Gerasimov, 1958) work in South China, places Canton on the Southern boundary of Red-Yellow Podsollic soils, and the Hong Kong area comes just within the yellow lateritic soil region.

#### SKELETAL SOIL (Lithosol:Syrosem)

Characteristics: Skeletal soils are essentially gritty, stony, or gravelly soils having no profile development other than a thin cover of fragmented, incompletely weathered rock and no humus horizon. The lack of eluvial and

illuvial horizons is the essential feature but characteristically they are not arable.

**Genesis:** Skeletal soils are embryonic. Apart from weathering of the surface material no profile development has taken place. In Hong Kong where weathering is intense, skeletal soils are found only where the forces of erosion remove the finer material as soon as it is formed. Mature soils, strongly differentiated from their parent material, which have only lost their surface horizons by translocation or erosion are not classed as raw or skeletal soils.

**Distribution:** There are surprisingly large areas of skeletal soil in Hong Kong. In those granitic areas which have escaped shattering and faulting there is a rapid surface water run-off and there is little opportunity for the water to sink in and initiate chemical weathering. Such areas are found to the south and east of Tai Lam Chung, at Chimawan, South Lamma, and Po Toi Island.

Lithosols also form in the mountain Peaks where the slopes are too steep to permit

percolation and chemical weathering.

Utilisation: Even the hardiest of trees find it difficult to establish on skeletal soils but if trees are planted in the pockets of slightly deeper soil in the skeletal areas, it would greatly assist in formation of useful soil.

### ALLUVIUM

Characteristic: Almost all of the agricultural soils of the Colony are alluvial in origin but cultural practices and various pedological processes have modified the parent material, developing what may be described as a more mature soil profile. The term "ALLUVIUM" has been restricted to those occurrences of alluvial material which are so juvenile that soil forming processes have not had time to develop the profile. Hence, although the soils may show considerable variation with depth, especially in textural characteristics of various layers, they have no true pedologic horizons. Because the soils are so immature they are very liable to change from season to season; consequently 'Alluvium' is not divided into drainage series though very often gleying

and mottling are strongly marked. The dominant characteristic of alluvium is its variability.

**Genesis:** The mode of formation of these soils is entirely sedimentary, different layers being due to successive additions of material different from or similar to that lower in the profile. The additions are derived by deposition from bodies of water, still or moving at various rates, the texture of the material being determined largely by the velocity of the water. The sands may be deposited by flood waters and the silts laid down by normal flow.

**Distribution:** Alluvium is found in small patches throughout the colony but is restricted in general to narrow strips alongside streams. Soil profiles are very quickly developed under rice production (q.v.) and the area designated 'Alluvium' is quite small. Most of the alluvium in Hong Kong is liable to frequent flooding, but where there are moderately secure patches vegetables may be grown, particularly in the winter when there is least danger of flooding.



SALINE SOILS (Solonchak):

**Characteristics:** The saline soils are gley soils that are or have been, in the not long distant past, affected by salt water from the sea and they have a wide range of salinity as shown by the crops and natural vegetation. The presence of soluble salts maintains a flocculated soil with no particular profile development. The soil normally bakes very hard in the winter with deep polygonal cracking and white or yellowish crystals of salt glisten on the surface. In the summer the fields become waterlogged easily and the mud is slick and greasy.

**Genesis:** Marine marsh terraces emerging from the sea and flooded by tidal waters result in formation of solonchak in various bays and estuaries in Hong Kong. Similar soils develop in marsh terraces in the Western Caspian and the processes involved have been described by Egorov (1944, Trudy Poshv.Inst.Dokuchaeva.44). Salinity is highest near the sea due to accumulation of  $\text{NaCl}$ ,  $\text{Mg So}_4$  and to a lesser extent  $\text{Ca So}_4$ . The salinity is thus of the

Ca-Mg-Na type. Further inland where brackish water rice is cultivated seasonal desalinisation predominates over seasonal salinisation and the Ca-Mg-Na suite of salts is replaced by a  $\text{Na}_2\text{SO}_4$  and a  $\text{SO}_4$ -Ca-Mg salinity.

**Occurrence:** The largest spread of saline soils is around Deep Bay but small extents are found also at Castle Peak, Sai Kung, Silvermine Bay and Tung Chung. Both low lying brackish water paddy areas affected by saline ground water, and the soils of marine flats and mangrove swamps are included in this group.

**Utilisation:** A slight salinity of less than 0.05% Na Cl is not harmful to rice and many of the areas growing high yields of fresh water paddy in Hong Kong show distinct traces of soluble salts especially in their deeper horizons.

Rice culture on gley-solonchak rice soils causes a reduction in the quantity of soluble salts to depths of 60-80cm, and an improvement in physical structure. These areas of vestigeal salinity are not considered as part of the solonchak area because in most cases the profile has been altered to

that of the normal poorly drained paddy soil.

There are large areas of solonchak soil planted to brackish water paddy and the salinity varies from season to season but when rice is being grown the irrigation water has a salinity of E.C.2,450 mhos/cm. and the topsoil shows 0.34% NaCl. Yields are high on the solon<sup>n</sup>chak but the quality is poor and only one crop per year can be grown.

Where the salinity is too high for rice, seagrass is grown.

Many of the areas between the seaward end of the brackish water paddy fields and the coastal strip of mangrove swamp are utilised for tambaks or fish traps (Chap. VI).

The only other widely represented World Soil Group in Hong Kong is the particular variation of gley soil induced by the wet cultivation of rice. The peculiar features of rice soils as represented in Hong Kong, are discussed in detail in the next section.

#### CLASSIFICATION OF HONG KONG SOILS

It has been found both simple and advantageous to divide the classification of Hong Kong soil into two separate formulae. The agricultural soils have been

classified on parent material and drainage, into associations and series, but the Hill soils have been mapped in broader categories based on geology and geomorphological situation. In many ways the two classifications are interlocking. The intensive land use on the rice soils and the complexity of the soil pattern demanded detailed survey, taking into account as many as possible of the soil factors which influence the yield of rice and vegetables. On the other hand, the hill areas have little actual or potential land utilisation and the soils are fairly uniform over wide areas though the topography and geology are somewhat confused.

#### Characteristics and Classification of Hong Kong Padi Soils

The wet cultivation of rice leads to formation of a soil profile which is, in many ways, as distinctive as the Podsol or the Chernosem. Padi may be grown on a wide range of Major Soil Groups but whatever the original profile may have been it is very quickly modified by the cultural practices of flooding, puddling and periodic draining. There are many methods of sowing, transplanting, weeding and harvesting rice but by and large they all involve shallow ploughing, thorough harrowing, flooding of the fields and wet ploughing to achieve a measure of



puddling in the top 3-7" of the soil. Throughout the Far East, the fields are too small to permit the use of mechanical implements and the farmers are often too poor to afford even draught animals for their ploughs so that deep ploughing is impossible. What is lacking in depth is made up in thoroughness. The top 6" of soil is either ploughed, or turned over by chankol and broken down by harrowing, both before and after flooding. The plough not only puddles the top soil but also with its flat sole, has a compacting effect on the layer beneath. Thus a puddled or 'sawah' structure is developed in the furrow slice and a hard pan is formed underneath. As however the rice plant is shallow rooted and water supplies are not necessarily drawn from the subsoil, comparatively little harm is done. The fields normally remain flooded for the greater part of the growing season and are finally drained and allowed to dry out when the crop has fully ripened. After the rice has been harvested the fields may be either left fallow or planted with a catch crop. Whatever the procedure it seldom happens that crops other than rice are grown for periods long enough to alter the soil profile imposed by the cultivation of rice.

The "Typical Paddy Profile" differs according to the natural drainage status of the solum, thus four main variants may be distinguished viz., the freely drained,

the imperfectly drained, poorly drained and very poorly drained. As seen when the field has been drained for harvesting, these profiles have the following characteristics.

Freely drained: The plough layer is usually gray brown (2.5 Y5/2) with a profusion of rusty and ochre mottles along root channels. Platy Structure occurs in top 3 cm. and the rest of the furrow slice has an angular blocky structure. The hardpan at 10-20 cm. rests on an iron pan which is most strongly developed in sandy soils. Generally the more compact and finer textured subsoils have a thinner iron pan than those of coarse texture which allow a freer movement of the iron. Beneath the iron pan there is usually an associated manganese discolouration which is more diffuse than the iron accumulation layer. The subsoil colour is startlingly bright in comparison with the drab grays of the plough layer, and it may have a variety of colours varying from the red of Krasnozem to the yellows of Red-Yellow

Podsollic, for the subsoil is virtually sealed off from the plough layer and is little affected by surface changes.

Imperfectly drained:      The plough layer is identical with that of the freely drained series but in the imperfectly drained profile the hardpan is less strongly cemented and the iron pan is less sharply differentiated.

The subsurface watertable fluctuates sufficiently to produce a BG horizon<sup>\*</sup> with both rusty ochre mottles produced by oxidation of iron compounds, and bluish gray 'gley spots' due to reduced iron compounds. In this BG horizon the structure is frequently prismatic with reduction gleying along

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\* All the horizons of paddy soils might be described as 'gleyed' because they have iron mottles throughout the profile but in dealing with the imperfect and poorly drained series it is important to distinguish the horizons of blue gray colour due to reduced iron compounds from horizons with black or ochre mottles produced by oxidised iron and manganese compounds. Kanno (1957) stresses the importance of this distinction and suggests that in describing paddy profiles the letter 'G' may be used to indicate reduced conditions whereas oxidised areas may be designated 'g'. This convention has been found to be very useful.

the prism faces and reddish yellow or black mottling inside the prisms.

Normally the prisms become progressively grayer with depth and the change to the G horizon is very gradual.

Occasionally the base of the BG horizon is marked by a secondary iron accumulation, and the transition to the bluish gray or whitish gray G horizon is very abrupt.

Poorly drained:

These soils are usually the most productive but they must be very carefully distinguished from the very poorly drained series which normally have a considerably lower yield.

The plough layer of the poorly drained paddy soil has a few rusty mottles along the root channels but there are many gray or whitish streaks and the matrix has a gray or dark gray colour (2.5 Y5/0 or 2.5 Y6/0).

Though there is a well marked hardpan, it appears to be formed more through mechanical compaction rather than chemical cementing and it is



fairly easily penetrated with a spade. There is no sudden transition from the hardpan to the underlying G horizon and there is no ironpan.

Very poorly drained: Here the water table is at or very near the surface and there is very little differentiation of profile apart from rusty mottling along root channels and a slight induration. Normally the very poorly drained areas are not very high yielding but if the water supply to these soils is flowing rather than very slow flowing or stagnant, the yield may be greater for there is less accumulation of reduced products toxic to the rice plant. Also if the waterlogged soils can be dried off slightly in the winter season it has a very beneficial effect on rice production. The BG is normally darker gray (5G 5/1) or more blue coloured (5BG 5/1) than in the better drained soils. Iron tubes are present when the water is moving but are absent if the soil is water-

logged in stagnant water. Textures in the very poorly drained soils tend to be heavy and massive sticky clays are not uncommon.

Within the furrow slice of a paddy soil the profile differentiation is often very marked and can provide a very useful indication of the productivity of the soil. The chemical changes which occur in a flooded paddy soil have received a great deal of attention but the accompanying physical changes in the furrow slice which are equally important in regulating the regime of the rice plant have been rather overlooked.

It has long been known that the most favourable texture for rice is a silt loam but the reasons for this have not been obvious. Partly the superiority of the silt loam may lie in its high percentage pore space (40%) which may prevent close packing, provides a more easily penetrable media for the roots, and permit freer movement of water (Romans 1959). In soils of this texture however a particular structure forms which is less marked in clay or in sandy soils. The soil particles which are in suspension in the surface water during ploughing and soil preparation, settle to form a layer of platy structure up to 3 or 4 cm. in thickness on the surface of the soil. This sedimented layer does not, however, rest directly on the reduced layer

but is separated from it by a very thin, but well marked, leached layer, whose bleached quartz grains stand out prominently against the rusty colour of the oxidised platy layer and the bluish gray reduced layer. Significantly there appears to be a tendency for the roots of the rice plant to avoid the bleached layer and it is often possible to lift off the capping of platy soil to uncover the grayish sand, without breaking any roots (fig. 14).

Doubtless the leaching is due to the action of nitric acid formed in the oxidised layer ( $\text{NH}_4\text{--HNO}_2\text{--HNO}_3$ ) and therefore plays an important part in the cycle, nitrification-leaching-denitrification by means of which the paddy soil loses so much of its nitrogen in gaseous form. (Shioiri, 1942; Mitsui, 1956).

It has been noted in Hong Kong that the highest-yielding soils within a particular drainage category are those in which the bleached layer is most marked. This may be partly due to the effect of the sandy zone in forming a barrier both chemical and physical to the passage of elemental nitrogen. The  $\text{N}_2$  or  $\text{N}_2\text{O}$  rising from the reduced layer will tend to be deflected by the discontinuity of media formed by the abrupt transition to a sandy layer. Furthermore the intense chemical activity of the leached zone probably absorbs a high proportion of the free gases.

Maintenance of this surface differentiation, with the leached zone free to develop, and the sedimented oxidised layer undisturbed, has been recognised in practice, if not in theory, by the Chinese farmers who do not permit anyone to walk in the field from the time the lower part of the stem begins to swell "for fear of interfering with formation of the grain" (Grist, 1953). In a series of experiments in 1935, Shioiri and Mitsui demonstrated the differences of oxygen supply and ammonium nitrogen which result when waterlogged soil is stirred up. These experiments led directly to the realisation of the part played by the oxidised and reduced layers in the nitrification and denitrification processes. Where textures are favourable (i.e. silt or silt loam) the oxidised layer may be up to three centimetres in thickness but in sandy soils it may be hardly detected. A complete well-developed paddy soil shows a sequence as in figure 12. The indurated layer may possibly be cemented by silica which is rendered soluble in the upper part of the reduced layer. The hard pan, together with the iron pan tends to form an impermeable layer which maintains the surface flooding. The latter feature is particularly necessary in freely drained soils and a very hard iron pan is formed. In more poorly drained soils the iron accumulation might be described as an orterde, being more diffuse. It does not occur at all in the very



poorly drained soils where there is no need to maintain an artificial water table.

Morphological features of rice soils tend to be confusing, especially when the subsoil water table fluctuates widely. It is most important that the horizons should be carefully studied and an appropriate symbol nomenclature be devised. Kanno (1957) suggests that the uppermost ploughed horizon should be designated Apg but in view of the importance of noting the presence, thickness and appearance of the oxidised layer it is suggested that the letters Apo (oxidised) and Apg (gleyed) be used for the sedimented and the reduced layers respectively. Following the usage of the U.S. Soil Survey Manual the indurated layer may be designated Ahg and this may be further subdivided by adding suffixes<sub>1</sub> and<sub>2</sub> if it is necessary to indicate the presence of a bleached ploughsole. Beneath the hardpan there may be both an iron pan and a manganese pan; these may be designated B<sub>2</sub>ir<sub>1</sub> and B<sub>2</sub>mn<sub>1</sub> and throughout the Bg horizon there may be other accumulation layers, mottles and streaks of manganese and iron. It is stressed by Kanno that these mottles should be carefully noted and described for they are important criteria in assessing the drainage class of the soil.

Use of a system of nomenclature as described above and illustrated in fig. 12 has proved of great assistance in

classifying the paddy soils of Hong Kong.

Such is the uniformity of morphological processes in paddy profile development that differentiation and classification of these soils is somewhat complicated and many investigations have been made into devising a useful classification. As early as 1935 Hou K.C. and Ma Y.T. had noted the importance of soil texture in classification of paddy soils. This effect was further clarified by Nag N.C. and Pain A.K. (1927) who pointed out that the silt and clay content of the soil is the most important soil factor determining paddy yields, optimum results being obtained from soils containing 40% silt (.002-0.05 mm.).

One might therefore assume that the most useful map of paddy soils would be a straightforward survey of surface textures but other factors such as water supply, mineralogical composition of parent material and height of the subsurface watertable are also very important.

Hou and Ma devised a classification based on differences of permeability and these distinctions corresponded in many respects with the "Mineralsche Nassboden" of Stremme (1936) and Kamoshita (1940). The vast volume of agricultural research in Japan has brought a much greater appreciation of the processes involved in formation of paddy soils. The most significant addition

to the literature on the morphology of these soils has been provided by Kanno who distinguishes five fundamental families of mineral paddy soils reflecting various degrees of hydromorphism. In Kanno's scheme, parent materials, and the kind, thickness and arrangement of horizons are taken into account but texture is not a primary consideration. Such subordination of texture is not, however, desirable in view of the connection between texture and yield.

In Hong Kong it has been found that a classification based on a Parent Material/Landform Association with the series forming a hydrologic sequence (Glentworth and Dion, 1949) provides a scheme which is readily mapped and is easily interpreted in terms of yield, potentiality and limiting factors.

The term Parent Material/Landform Association may appear to be rather unusual but for the purposes of paddy soil differentiation it is important to stress the importance of texture and the need for a very accurate assessment of the parent material. Three aspects of the basic matrix must be considered.

- (a) Parent rock.
- (b) Geomorphological nature of the parent deposit.
- (c) Textural characteristics of the deposit.

These three criteria must be taken into consideration when the soil associations are being classified for they

provide the theme on which drainage produces variations. Associations based on geology, geomorphology and texture are not as cumbrous and complicated as would appear. Sufficient information on the geomorphology can be obtained for mapping purposes, from interpretation of stereoscopic air photographs, and alluvial, colluvial, lacustrine or allochthonous soils may be easily distinguished. Furthermore the finer distinctions in textures are not critical at the Association level though it is important to separate the broad textural classes (sand, fine sand, loamy sand, sandy loam, loam, silt, silty clay, clay).

Within any particular Association on this basis, the main factor determining the productivity of the soil is its drainage. The term drainage has several meanings but here it refers strictly to the morphology of soil profiles. Four drainage series are recognised with characteristics as in fig. 13. Precise descriptions of the free, imperfect, poor and very poor drainage characteristics are possible only with individual series but the features described earlier in this paper are normal.

A uniform rock mass subjected to various weathering processes does not necessarily yield materials with uniform textures. Proportions of sand silt and clay in the weathered material vary according to the nature and intensity of the chemical and physical processes to which the



different rock exposures have been subjected. It is fairly simple in Hong Kong to distinguish the parent rock from which a particular material is derived but the characteristics of that material are different in different situations. Where the material has developed in situ it is very compact normally and is characterised by a predominance of clay sized particles. In the alluvial deposits derived from the same rock material, textures are predominantly silty, and colluvial materials have a more open, sandy texture. Within any one of these deposits broad variations in texture are most usually associated with slight differences in geomorphology e.g. the alluvial material derived from Volcanic Rocks in Hong Kong, may be subdivided as follows on the basis of texture and landform:

Lagoonal	Silty Clay
? <sup>ac</sup> Lacustrine	Silty Clay loam
River Channel deposits	Sandy loam
Deltaic deposits	Silt loam
Alluvial fan materials	loam

It is not always possible or necessary to identify every slight change in texture with some slight landform difference but with the combination of air photo interpretation and field data it is possible to build up a complete picture of the physical factors which control the distribution of the soil Associations.

An actual example may serve to illustrate the application of the Hong Kong paddy soil classification. One of the most widespread rocks in the colony is Tai Mo Shan Porphyry and it has weathered to form several Soil Associations. These associations correspond to landforms resultant on weathering and erosion of the Tai Mo Shan Porphyries as follows:

<u>Rock</u>	<u>Land Form</u>	<u>Association</u>	<u>Textures</u>
Tai Mo Shan Porphyry	in situ	Castle Peak	Clay Loam
	colluvial	Sun Hing	Very Mixed
	Boulder Fan	Sek Kong	Sandy loam
		Lam Tsuen	Fine sandy loam
	lacustrine	Chik Nai Ping	Silty clay loam

Theoretically each association has four series but in point of fact not all of the soils form complete associations e.g. neither a free nor a very poorly drained series has been found in the Castle Peak Association. The soil series may be divided into phases on the basis of soil characteristics not already taken into account. Such characteristics may be shallowness, stoniness or salinity. The most important criterion among these in Hong Kong is salinity. Part of an area occupied by soils of the Chik Nai Ping very poorly drained series is liable to flooding by sea water and

accumulated salts in the soil have a detrimental effect on productivity. In all other respects this soil is identical with its salt free counterpart, but mapping of the saline phase is of particular importance in Hong Kong.

Briefly the basis of the classification is differentiation of Soil Associations with reference to Geology Landform and Texture. Each Association may be divided into four series reflecting various degrees of hydromorphism. These series may be further subdivided in phases with differentiating characteristics such as salinity or stoniness.

#### Classification of Hill Soils

Having dealt at length with the classification of paddy soils it might be assumed that the hill soils which comprise 83% of the colony's area would require equally extensive explanation. This is not so. The soils which occur on the hillsides are both more uniform and less valuable than the paddy soils, accordingly they have been surveyed in less detail and more empirically.

The guiding factor was the need to devise a classification that would be of some use in deciding and implementing the most suitable land utilisation. It was at once obvious that for most of the hill areas, the best use of the land would be afforestation. Some of the

smoother plateaus on the Eastern peninsulas might support grazing animals but the poor quality of the herbage in the winter and the steepness of the topography, would almost certainly rule out cattle and it is doubtful whether sheep or goats could be grazed economically. The hillsides to the North and East of Tai Mo Shan show traces of former tea terraces but the scheme to grow tea in Hong Kong in the 1890's was a failure.

Afforestation is the only possible method of utilising most of the hill soils. A soil classification which can indicate the areas suitable for planting and the degree of suitability, would serve the needs of the moment. More detailed soil surveys should be carried out when it is decided to establish a forest in a particular area, but for the overall picture the general classification may suffice.

The main soil factors influencing tree growth in Hong Kong are (a) the level of plant nutrients and (b) the physical condition of the soil material whether loose, compact, stony, marshy or indurated. The first of these factors is governed mainly by geology and the second is often determined by geomorphology, therefore the hill soils of Hong Kong have been classified on the basis of Parent rock, and subdivided on a broad generalisation of the dominant landforms. The mountains of the colony are formed of five main rock types granite, porphyry, volcanic,



sedimentary and Metamorphosed sedimentary. Each of these rocks provides hill soil material in three main categories; skeletal, in situ, and colluvial, but these categories may require subdivision to indicate erosion of the in situ deposits or an excessive boulderiness in the colluvial material. Thus there may be five series on each rock type as in the following example

Rock	Nature of Material	Series Name
Granite	Skeletal	Tai Lam Chung
	in situ	Chimawan
	eroded	So Kun Wat
	colluvial	Shing Moon
	bouldery colluvial	San Hui

Classification of the hill soils on these lines is at best indicative of the general characteristics and distribution of the soils, but it must be stressed that this represents reconnaissance survey, and more detailed soil investigations may be required on areas where development is planned.

Owing to the difficulty of reproducing detailed maps of the whole Colony in a report of this nature, only the broad lines of the hill soil classification are discussed.

## Chapter V.

### THE SOILS

The geography and geomorphology of this area ~~is~~ are very complicated and the soils are subjected to very intensive cultivation so that slight differences tend to be emphasised and fine distinctions are often of importance in determining the land use. Each of the alluvial basins that comprise the agricultural land of Hong Kong has a complex pattern of soils, but the pattern tends to be repeated in most of the valleys so that some order emerges from what at first might appear to be a random distribution.

Twenty nine soil series have been recognised in the agricultural areas and have been grouped into nine large cartographic units (soil associations) on the basis of the nature of the parent material. In soil surveys in Britain and the United States it is customary to give each soil series a geographic name but it was felt that in Hong Kong a profusion of series names would confuse the extension workers who may wish to use the soil report. Accordingly only the associations have been given geographic names. Each series is identified by the association name and the drainage class, thus:- Chik Nai Ping Association, imperfectly drained series. All of the agricultural soils have been modified under paddy cultivation and their original

world soil group is not identifiable. Cultivated soils are therefore classed as paddy soils whether they have been formed on lateritic, solonchak or on red yellow podsollic materials. Where characteristics of a previous Soil Group may still be identified as in Castle Peak 'B' Association, the facts are noted in the soil description but the classification is based on the criteria laid down in Chapter IV.

In the following soil descriptions not every series is fully described. As the series are based on drainage distinctions which are common to each Association, complete descriptions of every soil series would tend to be repetitive. Although all the Associations are discussed in detail, only the more important series within each Association are accompanied by profile descriptions.

The field worker or extension officer who may be required to identify the soils in the field is not always directly interested in the laboratory analyses of the soils, therefore the analytical data for each profile is relegated to an appendix to this report, and only those laboratory results which have a direct bearing on the soil characteristics are listed with the descriptions.

#### The Soil Map

Because of the extreme complexity of the soil pattern and the intensity of land use in the Colony it was decided that no useful purpose would be served by reducing

the soil map of the paddy areas to a scale of 1 inch to 1 mile. The soils were mapped in the field on air photographs with an approximate scale of six inches to one mile and the data <sup>were</sup> ~~was~~ transferred to map sheets on the scale 1/25,000 or approximately 2½ inches to 1 mile.

It is seldom possible to draft a soil map which is self-explanatory. Most people can read a topographic map and many people are able to derive some information from a geological map, but it is seldom that even a trained pedologist can pick up a soil map of an unfamiliar area and grasp the significance of the series or classification without studying the accompanying report. Unfortunately the map of the soils of Hong Kong may be equally baffling unless it is studied in conjunction with this memoir; nevertheless the key to the soil map has been made as self explanatory as possible. The maps of the paddy soils are in the pocket at the end of the Atlas which accompanies this volume.

#### THE ASSOCIATIONS

##### CHIK NAI PING ASSOCIATION

The soils of the Chik Nai Ping Association are widely distributed throughout the Colony but are particularly extensively developed in the Kam Tin and Un Long areas. The first profile of this Association to be examined was found near the village of Chik Nai Ping to the west of the



entrance to Sha Tin Hoi or Tide Cove. Chik Nai Ping soils are derived from Tai Mo Shan porphyry material and are predominantly imperfectly or poorly drained with a silty clay loam texture.

### Distribution

The Association covers a wide area and occurs in each of the main valley units with the exception of Sha Tin and Mui Wo. The largest areas of this association are found in the basins surrounding Deep Bay but the most productive series occur in the Kam Tin area. For the most part Chik Nai Ping soils tend to occur in the middle of alluvial basins but where the association extends into the Deep Bay marshland near Au Tau, there is a saline series which is relatively unproductive.

### Parent Material

Chik Nai Ping soils are developed on lacustrine alluvium derived mainly from Tai Mo Shan porphyry material. From the texture of the soils and the situations in which they occur it is likely that the deposits were built up in freshwater lakes or in slightly brackish lagoons. In the top 3 or 4 feet the solum is remarkably uniform in texture and appearance but at depths of more than 48 inches a coarse white sand is frequently noted and at greater depths ( 72") a few marine shells have been found.

Series

All of the soils of this association have been planted to rice at one time or another but the freely drained series is now seldom planted with any crops other than peanuts or sweet potatoes and is normally left fallow.

Imperfectly drained series

Name?

This soil series has a moderately high yield of rice under favourable climatic conditions but in a poor year the yield is very much reduced because the surface soil tends to dry out very easily and surface cracking damages the roots. Sweet potato is the only vegetable which can be grown as a catch crop on this series and normally the land is left fallow in the winter.

LOCATION OF PROFILE: Kam Tin

YIELD: 200 catties per dau chung

Horizon Depth

Apg	0-5"	10YR 5/3 (Brown) fine sandy loam to silt loam, weak angular blocky. No stones, plentiful fine roots, well marked rusty mottling along root channels, moist, sharp change to.
Ahg	5-7"	2.5Y 5/4 (Light olive brown) silty clay loam, very compact, breaks with difficulty to small angular blocky structure frequent small air holes. A few fine roots occur associated

- with slight ochreous mottling. Sharp change to.
- B<sub>2</sub>ir<sub>1</sub> 7-10" 7.5 YR 5/6 (Strong Brown) silty clay loam, slightly platy structure, strong iron accumulation, slight Manganese staining at top of horizon gradual change to.
- B<sub>2</sub>mn<sub>2</sub> 10-20" 10YR 4/2 (dark gray brown) clay loam, strongly prismatic, clay accumulation along prism faces, few fine roots, frequent large flecks of manganese and slight increase in rusty mottling at base of horizon.
- B<sub>2</sub>ir<sub>2</sub> 20-32" 10YR 5/6 (yellowish brown) clay, large prismatic as above but with large iron mottles, slightly moist gradual change to.
- B<sub>2</sub>mn<sub>2</sub> 32" 10YR 6/3 (Pale brown) Sandy clay loam, massive, large flecks of manganese (5YR 3/4; 5YR 2/1), quartz grains, moist, roots beyond depth of pit.

The above profile is typical of many imperfectly drained pits which have been examined. The reaction of the soil is slightly acid at the surface (pH 5.00) but increased to pH 6.7 in the B<sub>2</sub>ir<sub>2</sub> horizon and remains constant at 6.3 - 6.4 throughout the rest of the profile. Lack of water is the primary factor preventing higher yields but the subsoil has a high exchangeable Na (0.90 m.e./100gm) and this would

also tend to depress yields.

Chik Nai Ping: poorly drained series

This series forms the best rice soils in the Colony; yields of up to 400 catties have been obtained with careful addition of fertiliser but normally the yield is 350 catties and even without regular fertiliser treatment 250-300 catties are harvested. Vegetables are regularly grown in the winter.

LOCATION: Tai Hong Wai (Kam Tin)

YIELD: 350 catties

Horizon Depth

Apg	0-8"	10YR 4/2 (dark gray brown) Silt, platy at surface merging into weak crumb. Abundant strong roots, rusty mottles along root channels, no stones, wet gradual change to.
Ahg	8-12"	10YR 4/2 (dark gray brown) silt loam, compact breaking to medium angular blocky, many fine roots very slight rusty mottling but marked 'gley spots'.
Bg	12-21"	10YR 5/3 (Brown) Silt loam, weakly prismatic, very thin clay coating on prism faces, frequent large mottles of iron and manganese with occasional large blue gray reduction mottles increasing in size and number towards



the base of the horizon, some fine roots,  
gradual change to

Bg 21-30" 10YR 5/4 (Yellowish Brown) Sandy clay loam,  
weakly prismatic; a few small black con-  
cretions, otherwise as above.

G 30"-38" 7.5YR 4/0 (dark gray) sandy loam, single grain  
structure. Occasional very distinct rusty  
mottles at top of horizon. Wet.

The fairly sudden change in texture in the G horizon  
is often marked by a secondary iron and manganese pan and  
the texture frequently degenerates at depth into a coarse  
white quartz sand.

Where vegetables are grown in winter on soils of  
this series the paddy yield may be raised by more than 20%  
due to residual effect of fertilisers. There are not many  
instances of soils of the Chik Nai Ping series being planted  
to vegetables all year round but where this occurs the  
productivity is not as high as might be expected and Fanling  
Association soils are superior.

Chik Nai Ping: very poorly drained series

Soils of this series are found mainly in the Deep  
Bay area and often have a saline phase near the Deep Bay  
marshes. Some very high yields and some very low yields  
of rice are obtained on soils of this series, dependent on

the salinity. Often soils which are indistinguishable morphologically are quite different in response to cropping. Where the salinity is below 0.1‰ two crops of rice are possible and up to 350 catties per dau chung (per crop) may be obtained but where the salinity is between 0.1 and 0.6‰ the yield drops to 150-200 catties and at salinities greater than 0.6‰ only one crop of brackish water paddy per year may be grown.

LOCATION: Pak Wai Tsuen (Kam Tin)

YIELD: 350 catties per day chung.

Horizon Depth

- |     |        |                                                                                                                                                                                                                                                                          |
|-----|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Apg | 0-7"   | 2.5Y5/4 (Light olive brown) Silt loam, platy, on top $\frac{3}{4}$ " of horizon (Apo), but soft weak medium angular blocky underneath; moderate organic matter, plentiful rice roots, very well marked iron pipes along root channels, no stones, moist sharp change to. |
| Gh  | 7-10"  | 5Y4/1 (dark gray) fine sandy loam, firm angular blocky, slight organic matter, a few fine roots some slight rusty mottling, moist.                                                                                                                                       |
| G   | 10-16" | 10YR5/1 (Gray) Silt loam, firm prismatic, slight organic matter, fine network of roots and clay along prism faces, no rusty mottles but several large whitish gray gley spots, wet, gradual change to.                                                                   |

- 15-20" 2.5Y5/2 (Gray brown) Silty clay loam, soft prismatic tending to massive structure, high concentration of clay and organic matter along structure faces. Occasional very rusty mottles, strongly decomposed stones, wet.
- 20-36" 2.5Y3/1 (very dark gray) Clay loam, massive, firm strongly marked iron pipes along old root channels, frequent undecomposed pieces of banyan(?) leaves at a depth of 32 inches. Very wet at base of horizon.
- 36" + 2.5Y 7/2 (light gray) Coarse sand and fine gravel, wet, with frequent woody remains.

In spite of the noticeable Apg horizon, the above profile is typical of the very poorly drained series of the Chik Nai Ping association. None of the other associations have such a well developed prismatic structure and very few of the other soils show such well marked evidence of recent formation in the form of organic matter in the G horizon. Occasionally there are soils of this series which give a slight response to phosphate but for the most part high yields are obtained with no addition of fertiliser.

#### FANLING ASSOCIATION

Fanling soils are the easiest to identify in the field yet are the most difficult to classify. The typical

diagnostic feature for the Association is the black colour throughout the greater part of the profile. The series are somewhat confusing and often a soil which would appear to be very good, grows very poor crops of rice under normal conditions. The reason for this difficulty in classification lies in the intensity and persistence of the black colour which obscures some of the mottling and conveys an impression of rich reserves of plant food. From the situations in which they are found and the high organic content, it is probable that Fanling Association soils are formed in areas of mangrove swamp or slightly peaty conditions during the drying up of lagoons or freshwater lakes.

Very similar soils have been described by Thorp, (The Geography of the Soils of China, 1936) and the Lankong series described by Pendleton (Reconnaissance soil survey of Part of Kwangtung Province, 1933) is obviously very closely related. As in the Lankong series the white subsoil of the Fanling association is excavated and is used in glassmaking. In most profiles the abrupt transition from the black clay or clay loam surface deposit to the fine white sand or clay subsoil is most marked, but in the more freely drained series the subsoil may be a mottled layer similar to the "fleckenzone" of laterite.

Near Lowu the white subsoil is excavated for glass-



making and is composed of a very fine sand which is more than 90% pure quartz indicating very extreme leaching conditions. Samples of this material have been successfully used in packing leaching columns for the semimicro determination of cation exchange in the soils laboratory but the sand, though pure, tends to be too fine to permit adequate drainage of the leaching columns.

In terms of acreage Fanling soils are not very important but in terms of utility they rank in importance with Chik Nai Ping. Though small patches occur elsewhere the greatest extent of black soil is in the Fanling and Takuling areas and more than 80% of the intensive vegetable growing occurs on Fanling Association soils or on material which has a horizon of black soil within the solum.

Because most of the soils of this association are planted to continuous crops of vegetables it is often very difficult to find a field in which to dig a profile and the lab. results of soil from a nightsoil treated vegetable field would be misleading in relation to most of the other paddy soil analyses. However wherever possible, profiles have been related to both paddy and vegetable growing conditions.

Fanling Association: imperfectly drained series.

Soils of this series occur mainly in the Takuling area and are notable for a fairly low yield of rice (200

catties/d.c.) but where adequate water is available to grow vegetables, the same soils have a high productivity.

LOCATION: Sheung Shui crossroads.

YIELD: 220 catties.

Agriculture Note: Rice still grown in profile field but all fields round about planted to vegetables.

Horizon Depth

Apg	0-5"	10YR6/2 (light brown gray) fine sandy loam, platy on angular blocky, moderately compact, plentiful fine rice roots, moderate organic matter, faint rusty mottling along root channels, sharp change to.
Ahg	5-8"	10YR4/4 (dark yellowish brown) loam, small angular blocky, hard and brittle, slight organic matter. Some fine rusty roots frequent quartz grains moist. Very thin iron pan along lower boundary of horizon, sharp change to.
Bg	8-20"	2.5Y 2/0 (black) Silt loam, weakly platy soft angular blocky, gray mottling along old root channels, moist gradual change to.
	20-30"	10YR 5/6 (Yellowish brown) Silty clay loam slightly prismatic, rusty mottles and

occasional small gley spots occasional  
quartz grains, moist.

30"+ 10YR 7/6 (yellow) Silty clay loam, massive  
with predominantly ochre but some long red  
and gray streaks, no roots, moist.

Only 12" of the above profile are of really black  
material and this is a typical feature of some of the better  
vegetable soils particularly if the overlying 8-10 inches  
are formed of material with good loam texture which can be  
easily worked yet does not dry out too quickly.

Fanling Association: poorly drained series

Higher yields of rice are obtained on this soil than  
on the imperfectly drained series but occasionally the soil  
is not quite so suitable for vegetables because the surface  
material if allowed to dry out, forms very hard aggregates  
which are with difficulty rendered into a good tilth.  
Unless treated with lime this soil tends to be very acid  
and reactions as low as pH 2.3 have been recorded.

LOCATION: Ping Che

YIELD: 200 catties per dau chung

Horizon Depth

0-6" 10YR 4/4 (Dark Y. brown) Silty clay loam  
angular blocky, no stones plentiful fine roots,  
moist, frequent rusty mottles especially

- along root channels. Quartz grains occur.  
Irregular boundary merging over 4 inches.
- 6-16" Black silty clay loam, massive to angular blocky structure, no stones, no quartz grains, frequent fine roots carry down of surface material along worm tracks, moist, no mottling, faint gray stains along root channels, irregular boundary.
- 16-33" 10YR 3/3 (dark brown) Clay loam, blocky, shiny clay on ped faces, individual peds hard and discrete, no stones, occasional roots, some Ochre mottling diffuse change to.
- 33-44" 10YR 4/3 (Dark brown Clay), prismatic, otherwise as above.
- 44" + Rotten stones, coarse sandy loam.

The above profile is atypical in so far as there is no white sand gley horizon but in a nearby storage pit quartz sand occurs at depths of 48 - 56 inches and it was noted that some of the dark coloured material from the BG and G horizons turns white on drying. Good crops of vegetables may be grown on this soil but a sandier surface horizon is preferable.

Fanling Association; very poorly drained series

Soils of this association have normally a very low yield of rice and are not very suitable for vegetables

2



unless the texture of the surface soil can be lightened by the addition of sandy material during the formation of bunds or terraces. Wherever deposits of this black soil are found, considerable relocation of horizons is practised. If soils of another association are underlain by Fanling material the farmer may apply some of the black subsoil as a top-dressing and conversely a stiff clay topsoil may be improved by mixing with sandy loam from the subsoil.

LOCATION: Ping Che (Takuling)

YIELD: 150 catties per day chung.

Agricultural Note: Water table tends to be of stagnant or very slow-moving water.

Horizon Depth

- |    |       |                                                                                                                                                                                                                                         |
|----|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ap | 0-6"  | 10YR 4/4 (dark yellowish brown) Clay, angular blocky, no stones, plentiful fine roots, wet, large well developed rusty mottles along root channels, quartz grains occur near base of horizon. Irregular boundary merging over 4 inches. |
| G  | 6-16" | 10YR 3/1 (Very dark gray) clay massive to angular blocky structure, no stones, no quartz grains, frequent fine roots, wet, well marked light gray staining along channels, irregular boundary.                                          |

- 16-33" 10YR 3/3 (dark brown) Clay, angular blocky, shiny clay on ped faces, individual peds hard and discrete, no stones, occasional coarse roots some large bluish and white gley spots. Gradual change to.
- 33"+ Coarse loamy sand, very wet, many stones. Excessive water and unpleasant smell prevented further identification.

Although poor crops of rice were grown in the field in which the above profile pit was dug and sampled, the laboratory analyses showed a high reserve of plant nutrients and the loss on ignition was high. The local farmers say that this soil is not very good if the dark material appears at the surface but if the same material is overlain by up to 12" of light brown silt loam (Chik Nai Ping) material very high yields are possible.

Much more work needs to be done on this soil type and it is possible that the series differentiation which is applicable to other soils requires modification in the assessment of the productivity of Fanling Association soils.

#### MAI PO ASSOCIATION

The Mai Po soils are very similar to those of the Chik Nai Ping Association though the former are neither so extensive nor so productive as the latter. Rice yield is 200-350 catties per dau chung on this soil which is

found mainly in the Mai Po, San Tin, Sheung Shui districts, and in pockets of agricultural land along the border from Lok Ma Chau to Lo Wu and Ta Kwu Ling.

Mai Po soils may be described loosely as Chik Nai Ping soils with a fine sand, rather than a silty texture. There are however other differences more noticeable in laboratory analysis than in field identification that justify separation of this association.

Mai Po Association is formed on alluvial and colluvial material derived from rocks of the Lok Ma Chau Formation but affected also by Tai Mo Shan Porphyries. This association is dominantly represented by the freely drained series which provides excellent vegetable soil if irrigation water can be led to the fields, but rice is grown only on the poorly drained and very poorly drained series.

A typical poorly drained profile is described below.

Mai Po Association: Poorly drained series

For the most part this series is associated with the Deep Bay depression and the greatest extents occur in the Ha Tsuen-Ping Shan area. Normally two crops of rice are obtained and tomatoes are grown as a catch crop in the winter. Although the soils are quite suitable for vegetables all year round, they are seldom so employed, partly because communications are poor in the areas where

Mai Po soils occur but also because the irrigation water tends to be inadequate and the soils are frequently slightly saline.

LOCATION: Ha Tsuen

YIELD: 250 catties per dau chung.

Horizon Depth

Apg	0-4"	10YR 3/2 (very dark gray brown) fine sandy loam, angular blocky structure, plentiful fine roots with well marked rusty pipes and occasional large flecks of ochre mottling, no stones or quartz grains, dry, sharp change to.
Ahg	5-12"	10YR 5/6 (brownish yellow) fine sandy loam, very strongly compacted, slightly prismatic, clay skin along structure faces. The horizon has a large number of small pinholes which do not seem to be caused by roots because they are not associated with mottling. Some fine roots, no stones slight increase in clay accumulation at base of horizon sharp change to.
B <sub>2</sub> 1r <sub>2</sub>	12-14"	5YR 5/6 (yellowish red) Sandy loam, iron pan with slight platy tendency and a marked darkening due to manganese at the base of horizon. Sharp change to
BG	14-32"	7.5 YR 4/0 (dark gray) Sandy loam with weak



prismatic structure, very compact, frequent large white and bluish white gley spots. There are very few roots and no rusty mottles.

32 + As above but with increasingly coarse sand fraction.

There is a steady decrease with depth, in the pH of this profile. At the surface pH 4.93 was recorded but at a depth of 36" the pH had dropped to 2.6.

Mai Po Association: very poorly drained series

Soils of this series cover a large area in the Deep Bay district but they are not important agriculturally because of the danger of flooding in such a lowlying situation, and many of the soils are saline. In the fields around Ha Tauen, Yuen Long and San Tin it is frequently impossible to differentiate, in the field, between saline and non saline phases of the same soil. One field may yield only 1 crop per year of poor quality brackish water rice while an adjacent field with an apparently identical soil will support 2 crops per year of high quality rice. At the farthest seaward limits of the soil there are however distinct signs of salinity, especially in the dry season when the topsoil dries out into hexagonal blocks with cracks up to two inches wide and small accumulations of long, needle-like salt crystals on the surface.

LOCATION: San Tin

YIELD: 200 catties per dau chung.

Horizon Depth

- Apo      0- $\frac{1}{2}$ "      10YR 4/4 (Dark yellowish brown) Clay loam, weak platy structure, no quartz grains visible to naked eye. Horizon varies in thickness, being thinnest at the plants and up to inch thick between the plants. No mottling, moist, sharp change to.
- Apg       $\frac{1}{2}$ -6"      10YR 4/2 (Dark gray brown) Clay Loam, weak prismatic structure, well developed fine roots, no stones but a few quartz grains, many prominent gray and rusty mottles, gradual change to.
- G      6-16"      2.5 Y 3/0 (Very dark gray) Clay loam, weak prismatic structure, firm, no stones, abrupt change to.
- G      16-24"      10YR 4/1 (Dark gray) Sandy clay loam. Weak prismatic structure at top of horizon becoming massive at depth, firm, a few quartz grains, wet, diffuse change to.
- G      24-30"      10YR 4/1 (Dark gray) Sandy clay loam, massive, several small pebbles rounded but undecomposed, water came quickly into the profile pit at 24" depth so it became difficult to observe

features of this horizon but a few very dark brown woody remains were seen.

Flooding with water hindered proper description and sampling of the wetter and more saline phases of this soil but as far as could be ascertained most of the more recent alluvial material in the Deep Bay depression has profiles similar to the above but there is an increasing fineness in texture nearer the sea, and in the completely uncultivated marshlands the general soil texture is a silty clay.

Every year there is a gradual extension of the marshlands and according to economic conditions the acreage under brackish water paddy and seagrass may be increased by bunding and cultivation further out into the depression. The seaward limit of the Mai Po Association roughly corresponds with the limit of present cultivation and it seems probable that if the swampland could be drained and irrigated with fresh water, the soils which would develop there would be very similar to the Chik Nai Ping Soils.

If reclamation of the Deep Bay area could be undertaken the agricultural improvements would not be restricted to the addition of a further 5-10 square miles agricultural land but also the existing agricultural soils of the Mai Po very poorly drained series would be very greatly improved.

The soils would be suitable for vegetables if the salinity could be reduced and the supply of fresh irrigation

water improved. In the Ha Tsuen area there has recently been a marked increase in the area of Mai Po very poorly drained soil planted to catch crops of tomatoes, and other salt resistant crops may be introduced.

#### CASTLE PEAK ASSOCIATION

Red soils which are derived from red clay beds of the Lok Ma Chau formation and the lateritic formations in the Colony are designated the Castle Peak Association. These soils occur in Castle Peak, Kam Tin, Ping Shan and Sheung Shu. This association is the only 'in situ' paddy soil in the colony and arises where low islands or shallows existed in the alluvial basins; thus Castle Peak soils frequently have a thin surface horizon of alluvial derivation but the greater part of the solum is formed of 'in situ' material. Good crops of rice are grown and yields of 250-300 catties are obtained though if the soil is saline as it is near Castle Peak Bay, an unfavourable structure (Sodium Clay) develops and poor crops result. Frequent quartz fragments and iron concretions are found in the soil but the layer of concretionary nodules seems to vary from area to area with little regard for drainage or other morphological reason. The whole range of drainage series is represented by this soil but in the poorly



drained and very poorly drained series there is of course considerable modification. The organic matter content is invariably low and the soil is seldom used for vegetable farming, though dryland crops such as groundnuts or sweet potatoes may be grown on the freely drained series.

Castle Peak Association can normally be easily recognised by the bright red colour of the soil which is very persistent and occurs even in the poorly drained series, though in the very poorly drained soils it may be restricted to a reddish tint in the topsoil.

Castle Peak Imperfectly drained series.

In most of the agricultural areas of the colony there are small mounds on "islands" of 'in situ' material which stick up through the blanket of alluvial soil, and in many cases these low hills are surrounded by a small extent of soils of the Castle Peak imperfectly drained soils. The largest areas of this soil are however found in the Castle Peak - Ping Shan areas and in the Kam Tin district. Soils of this series have a particularly well developed Apo horizon and moderately high yields of rice are normally obtained. A typical profile is described below.

LOCATION: Ping Tse (Takuling)

YIELD: 300 catties per dau chung.

Horizon Depth

- Apo 0-1" 10YR 6/3 (pale brown) Sandy clay loam, well developed platy structure with a very thin layer of coarse sand at the base of the horizon. There are no mottles but the laminae appear to alternate reddish-brown and yellowish brown. The surface bakes hard between plants. A few strong roots are noted in this horizon.
- Apg 1-5" 5Yr 5/2 (reddish gray) Sandy loam, angular blocky to slightly prismatic with fine crumb material along root cracks, strong development of fine roots along prism faces, rusty pipes along roots and faint orange mottling within the peds. Sharp change to—
- Ahg 5-10" 5YR 6/2 (pinkish gray) Sandy clay loam, sharp angular blocky, very hard and compact, abundant small quartz grains and some concretions at base of horizon. Slight rusty mottling, moist, sharp change to—
- Bg 10-22" 2.5 YR 5/8 (red) clay loam weakly prismatic, occasional quartz grains, some strong roots along prism faces, moist, frequent yellowish red mottling associated with small decomposed stones. Vague boundary with—

B/G 22" + 7.5YR 7/0 (light gray) Clay loam with large rusty mottles and long streamers of red (LOYR 5/8) material from upper horizon. The structure is massive and there are frequent large irregular shaped masses of slightly whiter clay within generally clay loam matrix.

The G. horizon occurs at a slightly greater depth in the above soil than is normal in imperfectly drained profiles but in the freely drained series of the Castle Peak Association the water table is occasionally at 36" from the surface but is more frequently at much greater depths.

Organic matter is low throughout the profile and the reaction is only slightly acid, rising from pH5.8 at the surface to pH6.4 in the BG horizon.

Agriculture on this soil is normally restricted to two crops of rice per year with no catch crop in the winter but in the Tuen Moon-San Hui area a small acreage is devoted to vegetables, with moderate success.

Castle Peak Association: Poorly drained series

Most of the soils of this series are found in the Kam Tin, Yuen Long and Castle Peak where they are mostly planted to two crops of rice and a winter catch crop of vegetables. Yield of rice is fairly high but the soils are not very suitable for all year round vegetables, though very good crops of water chestnut are grown.

LOCATION: Castle Peak

YIELD: 300 - 350 catties per dau chung

Horizon Depth

- |     |        |                                                                                                                                                                                                          |
|-----|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Apo | 0-1"   | 10R 6/4 (Pale red) Silty clay, strong platy structure, well marked alternation of light and dark coloured layers. Moist, sharp change to.                                                                |
| Apg | 1-7"   | 10YR 5/4 (Yellowish brown) Sandy clay loam, strong subangular blocky structure. No stones, no quartz grains, well developed system of fine roots with strongly marked rusty mottling, gradual change to. |
| Bg  | 7-15"  | 10YR 4/2 (Dark gray brown) Clay loam. Moderate prismatic structure, common rusty mottling, no stones but a few quartz grains, very firm throughout the horizon, gradual change to.                       |
| Bg  | 15-22" | 10YR 5/2 (Gray brown) Clay loam. Moderate prismatic structure, many prominent rusty mottling and some faint bluish gray spots, gradual change to.                                                        |
| G   | 22-32" | 2.5Y 4/0 (Dark gray) Sandy clay loam, massive, with occasional flecks and streaks of red (7.5R 6/4) associated with partially decomposed stones, no roots, water started flooding                        |



profile pit at 32" depth.

G      32" +      10YR 2/1 (Black) Sandy clay loam, massive,  
no stones, some quartz grains, no roots, no  
mottling.

#### CASTLE PEAK 'B' ASSOCIATION

The boulder fans forming Sek Kong Association in the Kam Tin basin extend over part of an area of Castle Peak soils and at the junction of the two parent materials there is a zone with soil which is formed on an intermixture of Castle Peak and Sek Kong materials. This soil is quite different in appearance and characteristics from either of the two major associations justifying its separation as an association in its own right.

Castle Peak 'B' Association may be recognised by its striking red colour which is characteristic of typical Castle Peak soils but there are a large number of stones and boulders which are in many cases cemented together with iron in a form of "Gallery laterite" (D'Hoore 1954).

A typical imperfectly drained profile is as follows:-

LOCATION:    Sek Kong

YIELD:    200 catties

Horizon    Depth

Apg      0-5"      2.5YR 5/2 (Weak red) Sandy clay loam, weak  
crumb, friable, plentiful fine roots, moderate

organic matter, a few quartz pebbles (up to 1" diam.) at base of horizon, plentiful rusty mottles slightly moist.

Ahg 5-10" 2.5YR 5/2 (Weak red) Sandy clay loam, very hard and compact, a few roots, very slight rusty mottling occasional quartz and porphyry pebbles, moist.

B<sub>2</sub>ir<sub>1</sub> 5-7" 2.5YR 6/6 (light red) Sandy clay loam, slightly platy structure, manganese staining at base of horizon, few strong roots, sharp change to.

B<sub>2</sub>mn<sub>1</sub> 7-20" 2.5Yr 5/4 (reddish brown) Sandy clay loam, subangular blocky, occasional pebbles up to 2" diameter, frequent large black flecks of manganese and a few strong roots penetrate to base of horizon. Gradual change over 9" to.

B<sub>2</sub>ir<sub>2</sub> 20-33" 2.5YR 5/4 (reddish brown) Sandy clay loam, massive structure and a very great increase in the number of stones. The stones are cemented with iron and digging is very difficult.

33" + 5YR 6/1 (light gray) Clay loam, massive with a few red flecks of red (10R4/6), no roots, wet.

## SEK KONG ASSOCIATION

The hills of Hong Kong have suffered serious erosion which has resulted in accumulation of large fans of bouldery debris on the flanks of the higher mountains. The most spectacular of these boulder fans are about the foot-slopes of Tai Mo Shan and give rise to two important soil Associations, Sek Kong and Lam Tsuen.

Soils of the Sek Kong Association are found principally on the northwestern slope of Tai Mo Sham in the Kam Tin basin but other areas are found, mainly in Tung Chung and Sai Kung.

The parent material is boulder fan debris and a matrix of finer material derived from rocks of the Tai Mo Shan Porphyries. Occasionally granitic or volcanic boulders may occur without markedly affecting the soil. There is normally a gradation in size of boulders, the largest being found at the apex of the cone, but even within the soil profiles it is noted that stones increase in size and number with depth. Provided sufficient water is available for irrigation the Sek Kong Association soils may be relied upon to give moderately high yields of rice and good crops of vegetables can be grown. Organic matter content is generally higher than in soils of most of the other associations and many of the soils are continuously cropped to rice with no fertiliser added. Analysis of

soil samples shows that the soils have adequate reserves of potash and phosphate but are slightly deficient in nitrogen.

Sek Kong Association soils are similar to those of Lam Tsuen Association but the latter have a higher percentage silt, and have a higher organic content.

#### LAM TSUEN ASSOCIATION

In many respects the Lam Tsuen soils closely resemble those of the Sek Kong Association and the mode of formation of the parent material is identical. In the formation of the Lam Tsuen valley certain factors of geology, geomorphology, and climate have combined to produce a soil which is quite different from the bouldery soils elsewhere in the colony.

#### Parent Material

The boulders of the parent material are mainly of Tai Mo Shan Porphyry but there is a slight admixture of Tai Po Granodiorite, and the faulting and dykes associated with the formation of the Lam Tsuen valley have supplied a quota of intrusive rocks. Generally speaking the larger boulders occur on the head of the valley and many of the rocks are more than 4 feet in diameter though the average size throughout the valley is about 6" diameter. The



debris is not well sorted and the boulders may be anything from 3" to 18" apart in a slightly sandy matrix. A surprising feature of the district is the roundness of the boulders suggesting that they have been transported in a river bed for a considerable distance. Stream abrasion is not however a tenable theory for the roundness of the stones because the distance of travel can scarcely be more than a mile or two. It must be assumed that the rocks assumed a rounded form under the influence of chemical weathering. Similarly rounded boulders are visible on the surface near the top of Tai Mo Shan where they resemble the perched boulders of glaciated regions. Indeed the whole of the Lam Tsuen parent material might be mistaken for the stony terminal moraine of a glacier, though the red colour and chemical features of the matrix indicate that it was derived from the products of tropical weathering.

### Distribution

This soil is found only in the Lam Tsuen valley where the combination of volcanic influence in the parent material, a favourable aspect with good shelter, and a more than adequate water supply have provided ideal conditions for cultivation of rice.

### Series

The whole range of series with the exception of

the very poorly drained series is represented in the Lam Tsuen association but the freely drained series is restricted to a small eminence between the villages Chung Uk Tsuen and Hang Ha and is not planted to rice though lychee orchards and dryland crops such as sweet potato and ground-nuts are grown.

Lam Tsuen Association: poorly drained series

Soils of the poorly drained series occur over the greater part of the Lam Tsuen Valley and are noted for high yield of rice, though they are seldom planted to winter vegetables. Up to 400 catties per dau chung may be harvested under favourable conditions but 300-350 is normal. In a series of fertiliser trials on these soils in the second crop period in 1958 and the first crop period of 1959, application of the three main elements gave no appreciable increases in yield as compared with the control and both phosphate and potash treatment tended to depress the yield.

A typical Lam Tsuen poorly drained profile is described below.

LOCATION: San Uk Tsai

YIELD: 350 catties per dau chung

Horizon Depth

Apo      0- $\frac{1}{2}$ "      2.5Y 4/2 (Dark gray brown) Sandy loam,  
slightly platy, no stones but frequent small

quartz grains, frequent strong roots, moist, abrupt change to.

Apg 1½-6" 10YR 4/2 (Dark gray brown) Sandy loam, weak subangular blocky structure, a few small stones and frequent quartz grains particularly around the main part of the rice plant roots. Prominent rusty mottling along the roots and a few bluish gray mottles between the rice plants, very moist, clear change to.

Ahg 6-15" 10YR 6/2 (Light brownish gray) Sandy loam, weak angular blocky structure, moderate compact but frequent fine roots penetrate horizon, many rusty mottling and a few small flecks of manganese, wet; gradual change to.

G 15" + 10YR 5/2 (Gray brown) Sandy loam, single grain, plentiful stones and a few fine roots. Many large whitish gray mottles increasing in size and number with depth. Water entered the profile pit at 28" depth preventing further observation.

The reaction is acid to very acid and the amount of organic matter moderate throughout the profile. A catch crop of flowers (gladioli) had been grown in the field but no fertiliser had been added. The rice yield is adequate for the farmers to maintain a comfortable living but there

is a growing trend towards greater intensification of vegetable farming and a few farmers are now growing catch crops in the winter. In the sheltered situation of the Lam Tsuen valley, flowers do particularly well and the soil is well suited to vegetable cultivation.

Lam Tsuen Association, imperfectly drained series

The imperfectly drained series occurs at the head and round the sides of the Lam Tsuen valley. The soils are all planted to two crops of rice but no catch crop is grown and the yields are seldom more than 250 catties per dau chung. Greater productivity could be gained from this soil if nitrogenous fertilisers were applied.

LOCATION: Lam Tsuen

YIELD: 250 catties

Horizon Depth

Apg	0-6"	2.5Y 5/2 (gray brown) fine sandy loam, angular blocky structure, some stones and some quartz grains. Abundant fine roots, slightly moist, frequent small rusty mottles sharp change to.
Ahg	6-11"	7.5YR 6/2 (pinkish gray) Silt loam, structureless but hard and compact, no stones, a few fine roots, a few rusty mottlings increasing in size and intensity towards the base of the horizon. Gradual change to.



- B<sub>2</sub>ir<sub>1</sub> 11-17" 7.5YR 5/6 (Strong brown) silt loam, crumb,  
no stone but frequent quartz grits up to  $\frac{1}{4}$ "  
in diameter, no roots slightly moist, frequent  
large rusty mottles. Gradual change to.
- B<sub>2</sub>mn<sub>1</sub> 17-28" 7.5YR 5/8 (strong brown) Sandy loam, weak  
subangular blocky, frequent stones up to 7"  
diameter, large flecks and stains of manganese  
with occasional greyish gley spots increasing  
in size and number with depth, wet.
- G 28-36" 2.5Y 6/2 (light brown gray) Silty clay loam,  
structureless, many stones as above, very wet.

The pH of this profile rises from 5.3 at the surface horizon to pH 6.3 in the B<sub>2</sub> and G horizons and the available phosphate is very low throughout the profile.

#### SUN HING ASSOCIATION

Not all of the debris cones at the foot of the hills of Hong Kong are bouldery; many of the smaller volcanic and porphyry hill areas have aprons of very mixed alluvial-colluvial deposits which form the parent material of the Sun Hing Association. Naturally with such a mixed percentage the soils are not so uniform over wide areas as most of the other Associations but the variations though frequent are so slight as to have little effect on crop response.

## Distribution

Sun Hing soils are well represented on the north side of the Kam Tin basin, the western side of the Castle Peak-Ping Shan valley, and in the Fanling-Shataukok district.

## Series

The whole range of series from freely drained to very poorly drained, is represented but the freely drained series soils are seldom cropped to rice though they are very suitable for fruit trees and pineapples do particularly well if an adequate dressing of fertiliser is applied.

### Sun Hing Association: imperfectly drained series

LOCATION: Lam Ti (Castle Peak)

YIELD: 150 catties

#### Horizon Depth

Apg	0-3"	10YR 4/2 (dark grey brown) gritty loam, weak crumb, friable no stones, frequent rusty coated quartz grains, abundant fine roots, slightly moist, very little rusty mottling (pH 6.7), sharp change to.
Ahg	3-5"	10YR 4/3 (brown) clay loam, very hard and brittle, but slight prismatic structure a few fine roots, no rusty mottling, slightly moist, (pH 6.6) gradual change to.

- B<sub>2</sub>ir 5-12" 10YR 6/6 (brownish yellow) gritty clay loam compact, angular blocky, no stones but frequent sharp quartz grains thickly coated with iron oxide, rusty stains along root channels (pH 5.0) gradual change to.
- Bg 12-20" 10YR 7/6 (yellow) Clay loam, angular blocky, a few fine roots, large white stains and streaks, frequent rusty mottles (pH 4.9) gradual change to.
- G 20-37" 10YR 6/1 (Gray) Clay, massive, no roots, very sticky and wet (pH 4.9).

Normally sugar cane is grown on this soil but the yields are not high probably because insufficient fertiliser has been applied.

Sun Hing Association: Poorly drained series

Many of the soils of this association are planted to vegetables but fairly high yields of rice may be obtained if nitrogenous fertiliser is applied.

LOCATION: Lam Ti

YIELD: 250 catties per dau chung

Horizon Depth

- Apg 0-6" 10YR 3/2 (very dark gray brown) Silt loam, weak platy structure at surface, on subangular blocky, plentiful fine roots, moderate to

high organic matter, slightly moist, frequent diffuse rusty and black mottles and fawn rusty stains along root channels (pH 5.7) gradual change to.

- Ahg 6-10" 2.5Y 4/0 (dark gray) Silt loam, platy structure, hard and compact, plentiful fine roots, no stones but several sharp angular quartz grains ( $\frac{1}{4}$ " diam.), large rusty mottles near base of horizon (pH 4.9) gradual change to.
- Bg 10-16" 2.5Y 5/0 (gray) sandy loam, single grain structure, a few small stones (1" diam.) abundant quartz grains as in above horizon, occasional large streaks of whitish clay, wet, (pH 4.7) gradual change to.
- 16-22" 2.5Y5/0 (gray) coarse sand, structureless, plentiful woody roots, no stones, wet (pH 4.7) gradual change to.
- G 22-39" 2.5Y 7/0 (light gray) very coarse sand structureless occasional angular stones increasing towards base of horizon, a few slight rusty mottles and some old blackened woody roots, wet (pH 3.9)

A noticeably high organic matter content is a feature of most poorly drained Sun Hing soils and it is probable that



areas occupied by these soils may have been wooded until quite recent times.

#### SHA TIN ASSOCIATION

It is surprising that although more than 30% of the native rock of the Colony is granite, there is only one paddy soil association formed on granitic materials. The Deep Bay Depression is surrounded for the most part by volcanic, porphyry, or metamorphic rock and all of the larger agricultural areas are based on soils formed from these rocks. There are numerous small pockets of cultivated soil in the granite hills but Sha Tin Valley and Mui Wo are the only agricultural areas where there are appreciable extents of granitic soil. There is a great variety of soil material derived from porphyry and metamorphic rocks, ranging from boulder fans to lagoonal silts, but all of the granite soils have similar features regardless of geomorphological situation. It is probable that if the area of granitic soils were greater it might be necessary to distinguish bouldery or lagoonal parent materials but a single association is adequate for all practical purposes.

#### Series

All four drainage series are represented in the Shatin Association and rice is grown on each series but

with widely different results. Yields as low as 80-110 catties per dau chung have been noted on freely drained series and up to 320 catties on the poorly drained soil. In the freely drained and imperfectly drained series a strong iron pan is very frequently developed and in all series the ploughpan is very hard and difficult to penetrate. These conditions are very satisfactory for vegetable and flower cultivation where the sandy topsoil forms a very suitable medium for short term highly fertilised crops. Almost all of the areas of Shatin Association soils are rapidly turning from paddy to intensive horticulture.

Shatin Association: Freely drained series

LOCATION: Hin Tin Village

YIELD: 100 catties

Horizon Depth

Apg 0-3" 2.5Y 6/4 (light yellowish brown) Sandy loam, crumb, friable, many fine roots, many quartz grains, very faint rusty mottling, dry, (pH 5.2), gradual change to.

Ahg 3-6" 5Y 6/4 (pale olive) Sandy loam, sub angular blocky, very compact a few fine roots, many quartz grains up to 3/8" diameter, (pH 5.1) sharp change to.

B<sub>2</sub>ir mn 6-10" 7.5YR 5/6 (strong brown) fine sandy loam,

hard, slightly platy with plentiful rusty mottles and several large manganese stained concretions, no roots, slightly moist, (pH 5.7) gradual change to-

B <sub>2</sub> mn <sub>2</sub>	10-17"	5YR 6/6 (reddish yellow) Fine sandy loam, structureless, many small quartz grains and occasional quartz pebbles up to 2" diameter, no rusty mottling but some manganese staining slightly moist, (pH 5.7), gradual change to-
	30" +	2.5YR 5/6 (red) Sandy clay loam, as above but more compact and with faint signs of gray or whitish mottles, moist. (pH 6.0).

The above profile is typical of many soils in the small valleys around Sha Tin and Mui Wo. The soil is very poor and grows barely sufficient rice to cover the expenditure on seed and labour. No fertiliser is applied and occasionally only one crop per year is possible because of lack of water. If the soil could be irrigated properly the yield could easily be doubled.

Shatin Association: Imperfectly drained series

LOCATION: Pak Tin Tsuen

YIELD: 150 catties.

Horizon Depth

Apg	0-4"	2.5Y7/4 (pale yellow) Sandy loam, subangular
-----	------	----------------------------------------------

blocky, abundant fine roots with faint iron mottling along root channels, dry. (pH 5.3)  
Gradual change to.

- Ahg 4-9" 5Y5/3 (olive) Sandy loam, very compact, structureless no stones, some fine roots, slight rusty mottling near base of horizon (pH 5.2) Abrupt change to.
- B<sub>1</sub> 9-16" 7.5 YR 6/6 (reddish yellow) sandy loam, very compact, a number of small rusty stained quartz grains slight manganese staining. (pH 5.3). Sharp change to.
- B<sub>2</sub>ir 16-19" 7.5YR 5/6 (Strong brown) Sandy loam, iron pan, very hard, no roots, stony, manganese staining at base of horizon (pH 5.4).  
Abrupt change to.
- B<sub>2</sub>mn 19-25" 10YR 7/6 (yellow) coarse sandy loam, subangular manganese stains, dry. (pH 5.3).
- B<sub>2</sub>ir<sub>2</sub> 25" + 10YR 6/6 (brownish yellow) Coarse sandy loam, subangular blocky, moderately compact, no roots, a few decomposed granite stones, rusty mottling throughout. Moist (pH 5.2)

The above profile is slightly drier than is usual for imperfectly drained series but the features are quite distinct from those of the freely drained Sha Tin soils.



Shatin Association: poorly drained series

LOCATION: Sha Tin agricultural station

YIELD: 200 catties

Horizon Depth

- |     |        |                                                                                                                                                                                       |
|-----|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Apg | 0-6"   | 2.5Y3/2 (very dark gray brown) Sandy loam, weak crumb under thin layer of platy structure, abundant fine roots, moist, frequent bluish and rusty mottles (pH 4.9), gradual change to. |
| Ahg | 6-18"  | 2.5Y 6/2 (light brown gray) Coarse sandy loam, slightly platy structure slightly compact, frequent rusty mottling a few fine roots, moist (pH 5.3) sharp change to.                   |
| BG  | 18-22" | 5Y7/1 (light gray) Coarse sand, single grain, no roots, numerous rusty mottles becoming smaller and fainter with depth (pH 5.1) sharp change.                                         |
| G   | 22" +  | 10YR 5/6 (yellowish brown) Coarse sand single grain very wet, no mottling.                                                                                                            |

Occasionally soils of this series have a subsoil of much heavier texture, and in these cases the soils are much more productive.

Sha Tin Association: very poorly drained series

LOCATION: Tin Sam

YIELD: 250 catties

Horizon Depth

Apg	0-6"	2.5Y 7/5 (yellow) Sandy loam, crumb on top of sub angular blocky structure, plentiful fine roots, moderately compact, no stones, frequent ochre and bluish mottles, (pH 5.2) gradual change to-
Bg	6-12"	5Y 5/1 (gray) Sandy clay loam, platy, more compact than above, abundant roots, frequent large quartz grains, many large rusty mottles and rusty stains on structure faces (pH 5.1) gradual change to-
BG	12-18"	2.5YR 4/0 (dark gray) Silty clay loam, massive, very few roots, no mottling wet, (pH 4.3) gradual change to-
G	18-36"	2.5YR 3/0 (very dark gray) Silty clay, large prismatic structure, slightly peaty, many partly decomposed woody roots, wet, slight H <sub>2</sub> S smell, (pH 4.5)

PEAT

There is no peat shown on the soil map and only two small deposits of basin peat have been discovered within the top six feet of soil in the Colony, one at a depth of 4 feet in Sha Tin valley and the other within a foot of the surface near Low Wu. It is probable that the rate of deposition of alluvium has been too rapid to permit peat formation.

Chapter VI.

AGRICULTURAL DISTRICTS

The agricultural areas of Hong Kong are small, compact, and highly individual units. Before the soil patterns of these areas can be understood it is necessary to have some idea of the geomorphological history of each unit. There is a striking correlation between the soils as mapped and the detailed land utilisation but frequently economic and social factors have played a decisive part in forming an agricultural pattern which cuts across soil differences. Partly to explain these anomalies and partly to clarify the apparent complexity of the soil map some of the more important agricultural areas are examined in relation to their geomorphology, soils, settlement and land utilisation.

A land utilisation and a productivity map are shown for each agricultural area, so that trends of future development may be assessed. The productivity index is the yield of rice and is quoted in catties per dau chung per crop. As the methods of cultivation, and crop periods, are almost uniform throughout, the rice crop is a reasonably reliable basis for assessment though it is realised that it is not an absolute guide because of district variations in availability of fertilisers, seed varieties,

irrigation schemes, conservative attitude of farmers or marketing difficulties. It is not possible to assess the productivity of vegetable land because the nature of the market requires an extreme flexibility of farming economy to take advantage of sudden changes in demand. There is also a diversity of vegetable crops some of which are seasonal and some of which may be grown continuously throughout the year.

The land use pattern is changing rapidly. The trend is toward greater intensification both by catch cropping in the winter and by converting paddy fields to vegetable gardens. In the following descriptions of the agricultural areas an attempt is made to forecast the direction of this trend and to show the physical and pedological factors which govern its distribution. It is recommended that the soil survey map should be studied alongside the current (1959) land utilisation map so that the most likely areas for future extension of vegetable farming be earmarked in advance, and settlement of immigrant farmers controlled so as to avoid the "mushroom" development of temporary structures which is a feature of the Fanling district (Plate 13).

KAM TIN (Figs. 19(a) and 19(b))

Kam Tin was one of the earliest areas to be settled by Cantonese farmers and it is in this area that the best



soils of the colony are found. The basin is slightly over 3000 acres in extent and the pattern of soil and land utilisation is typical of the majority of the agricultural districts. The basin is roughly diamond shaped, with one axis following the NE/SW trend of the dominant fault system and the other axis lying almost E-W, trending towards the Deep Bay depression.

#### Drainage

The basin is surrounded by steep hills and there are numerous small streams tributary to the Kam Tin creek which flows into the Deep Bay marshes. The creek is tidal up to the walled villages of Kam Tin and when a period of heavy rainfall coincides with a high tide there is frequently serious flooding in the western part of the basin. Because of the flatness of the valley the streams normally meander quite widely, but the soil of the hills has a very limited water holding capacity so that when there is heavy rain many streams change their courses and cause considerable damage to agricultural land. This is particularly true in the southern extremity of the valley where the streams from the granite hills carry large quantities of sand in their floodwaters.

#### Geology

For the most part the valley is surrounded by hills

of Tai Mo Shan porphyry. The one inch geology map shows a considerable extent of Tai Po granodiorite extending along the southwestern edge of the basin but indications are that the granodiorite is much less extensive and the soils are, almost without exception, typical of the Tai Mo Shan porphyry material.

Granite occurs at the southern end of the NE/SW axis and there are numerous small faults and dykes associated with the junction of the granite and porphyry.

Though there is only one small exposure of the Lok Ma Chau metamorphosed sediments, in the northern edge of the basin, there are several indications that rocks of this formation underlie most of the alluvial sediments. In the slightly higher land in the middle of the valley there is only a thin cover of alluvial deposit lying on in situ material developed on metamorphosed rocks, and in wells dug around the walled villages of Kam Tin there are exposures of talc schist and quartz sandstone.

### Soils

The soil pattern in the Kam Tin Basin is fairly simple and straight forward. Around the periphery there are alluvial fan materials of the Sun Hing Association and at the western end of the area there is a large spread of boulder fan material forming the type area for the Sek Kong Association. Embraced within the western edges of the

basin and extending in a low ridge as far as the walled villages there are residual soils on Lok Ma Chau porphyry material, with a thin covering of alluvium and forming soils of the Castle Peak Association. There is a variant of the normal Castle Peak soil here, represented by the Castle Peak B Soils which have an admixture of boulder fan material in their subsoil. A small extent of granitic soils of the Shatin Association fills the southern tip of the basin.

The productive Chik Nai Ping soils are grouped around the walled villages of Kam Tin and are formed of lacustrine alluvium, but where the soils are subject to flooding by tidal waters near the Kam Tin creek, the yields are low.

### Geomorphology

The dominant formative processes in the Kam Tin basin are (a) faulting associated with the Castle Peak - Deep Bay depression and (b) two faults through Fanling and Lam Tsuen converging on Ma On Kong in the southern tip of the basin and extending into the Tai Lam Chung fault.

When the area was occupied by the Cantonese 1000 years ago Kam Tin was a coastal settlement, and the whole basin at one time formed a sea inlet. Remnants of raised beach terraces up to 200 feet above sea level may be traced around the foothills. As the basin emerged from the sea alluvial material was deposited, but the character of the alluvium

varies considerably. A large boulder fan dominates the eastern end of the basin, extending from the slopes of Tai Mo Shan for a distance of more than two miles out into the basin. Two separate erosion cycles may be detected in this boulder fan; the most recent is probably associated with deforestation of the summit of Tai Mo Shan and may be little more than 1000 years old, but in stream cuttings near the village of Siak Tau Wai the bouldery material may be seen to overlies a comparatively thin (2-3') layer of marine sand which, in turn, rests on an earlier boulder fan. The earlier boulder bed may have formed part of a shingle bank on the former coastline of the basin but the deposit must have been quite extensive for it occurs also in the subsoil of the material mapped as Castle Peak B Association.

Near the Middle of the basin at Sek Kong, the seaward extension of the boulder fan was arrested by a low ridge of Lok Ma Chau metamorphosed sediments, which may be said to form the core of the depression.

At the outlet of the basin and around the Kam Tin villages lagoonal or lacustrine deposits are found.

#### Agricultural Pattern

The traditional economy is still dominant and the influx of immigrant farmers has been much more restricted in this area than in the Fanling or Un Long areas. A



small but steadily increasing number of vegetable farmers have settled alongside the road but the alluvial and lacustrine soils remain in the hands of Cantonese and the boulder or alluvial fan material is farmed by Hakka villagers. There is a plentiful supply of water and two crops of rice are grown throughout the valley and a winter catch crop is grown on all but the poorer stony or salty soils. All of the ploughing is done by the light local cattle and there are no buffaloes in this district.

Small orchards have been established beside most of the villages particularly on the foothills but there is plenty of room for expansion of fruit growing particularly in the freely drained series of the Sun Hing Association. Almost all of the cultivation is below the 25 metre contour line but on the northern and eastern edges of the basin pineapple, Japanese apricot and some of the harder citrus fruits would do well up to 100 metre contour with adequate terracing and irrigation water.

There is a herringbone pattern of old tea terraces on all of the northern slopes of Tai Mo Shun above Kam Tin and these might be replanted with tea or mulberry.

Neither fruit nor tea culture commends itself to the local farmers who are conservative in the extreme. Many of the fields could be made more productive if more

vegetables were grown but the cultivation of rice brings in an adequate income with less work than vegetable farming. Sale of village land or renting to outsiders is uncommon and only a few immigrants have managed to gain a foothold on the somewhat unstable patches of recent alluvium along the streams.

The sandy soils of Shatin Association in the <sup>S</sup>outhern tip of the basin are well supplied with water and are particularly suitable for vegetables. A new road is planned to link the villagers of this relatively inaccessible section with Castle Peak through Tai Lan Chung and with Kam Tin through Sek Kong. When the area is opened up to vehicular transport there is no doubt that there will be a considerable increase in the area under vegetables and flowers.

Only a small area alongside the tidal creek suffers from salinity but the soil is potentially valuable and if some means could be found to regulate the influx of brackish water, a higher yield of much better quality rice would be possible and the farmers around Kam Tin would have some security against the perennial worry of flooding.

An integrated scheme of flood control is very necessary in this type of basin with its very steep catchment and abrupt break of slope at the foothills. When rice was the only crop grown in the area the frequent floods

TABLE VI (a)

SURVEY OF CULTIVATED LAND AT KAM TIN

Village	Paddy (2 crops)	Paddy (2 crops) & 1 Catch-crop	Vegetable	Orchard	Misc. Crops	Up land Paddy (1 crop)	Flower Crops	Total <i>ACRES?</i>
She Po	107.56	132.52	35.44	2.00	35.84	-	-	313.36
Ko Po	80.68	100.12	11.60	7.60	5.92	-	-	205.92
Sek Wo Tong	86.60	251.08	15.40	3.60	4.80	-	-	361.48
Sek Wo Tong	53.56	166.48	5.96	-	-	-	-	226.00
Wing Lung Wai	160.52	120.56	60.08	12.88	16.44	-	-	370.48
Shek Kong	110.04	60.16	34.84	-	3.12	-	-	208.16
Wong Toi Shen	271.56	158.36	10.88	3.86	17.88	-	-	462.54
Shui Lau Tin	176.56	160.08	3.08	7.36	13.24	-	-	360.32
Ma On Kong	129.08	110.28	1.12	4.00	11.88	-	-	256.36
Shek Tau Wai	199.16	63.44	1.84	0.28	1.28	-	-	266.00
Kap Lung	54.96	-	-	-	4.32	-	-	59.28
Total	1430.28	1323.08	180.24	41.58	114.72	-	-	3089.90

did little damage but land hunger and the need for irrigation water has driven vegetable cultivators to utilise the mixed bottom land of streams where both houses and crops are in danger of inundation. Part of the problem may be met by the catchwater channel which is being built along the southern edge of the basin but many of the streams require thorough cleaning out, and where the river has wide meanders the banks require strengthening by piles or sand-bags.

#### LAM TSUEN/TAI HANG (Figs. 20a and 20b)

##### Description

The Lam Tsuen is one of the most interesting as well as one of the most fertile of the valleys of the New Territories. Extending for 4 miles from Pak Ngau Siak on the slopes of Tai Mo Shan to Tau Pass near Fanling, the district here referred to as Lam Tsuen-Tai Hang, forms a straight, narrow, and almost rectangular valley, divided into two equal sized compartments by a transverse ridge of low hills (Plate 8).

##### Drainage

The drainage of the Lam Tsuen-Tai Hang valley is the reflection of a complex geological and geomorphological history. The southern portion of the area is drained by



the Lam Tsuen stream which rises on Tai Mo Shan and follows the NE - SW trend of the valley for two miles but at Hang Ha Po suddenly bends sharply eastwards to cut its way (plate 7) through a narrow defile and flows out to the sea at Tai Po. The Tai Hang half of the area is drained by a stream which flows into the Fanling-Sheung Shui plain.

### Geology

The valley lies along a line of structural weakness. Though in the 1" map the geology appears to be fairly simple, more detailed field work indicates that it is greatly complicated by dykes and a series of minor transverse faults or cleavage lines. One such diabase dyke marks the pass between Lam Tsuen and Sek Kong and another dyke forms the core of the septum which divides the Lam Tsuen from the Tai Hang valley.

### Soils

In spite of geological and physical affinities of the two halves of the Lam Tsuen-Tai Hang district, the soils and agriculture are strikingly dissimilar. The Lam Tsuen section has its own Soil Association dominated by one of the boulder streams which streak the flanks of Tai Mo Shan. The Parent Material is predominantly derived from Tai Mo Shan Porphyry but the soil is modified by the Tai Po Granodiorite which imparts a more open texture and

a freer drainage. Only two small outcrops of the granodiorite have been found in the Lam Tsuen valley and it is very probable that the granodiorite is more limited in extent than is indicated on the geology map. Nevertheless the freer draining properties of the soil and the ample supplies of water render the valley exceptionally fertile.

Soils in the Tai Hang Section of the valley follow the more conventional pattern for Hong Kong, having materials of the Sun Hing Association at the foot of the hills and Chik Nai Ping soils in the middle of the valley. Sun Hing soils resemble the Lam Tsuen soils in so far as both associations are developed on boulder or alluvial fan materials but the Sun Hing parent materials are less well mixed and not so productive as the Lam Tsuen Association.

#### Geomorphology (Fig. 16)

The most striking feature of the geomorphology of this district is the tremendous boulder stream from 10 - 40 feet in thickness throughout most of the southern section of the valley. Near Pak Ngau Siak the boulders average 3 - 4 feet in diameter but two miles further down the valley the average boulder size is 6". The origin of these boulder streams around Tai Mo Shan is obscure for it is difficult to conceive of a stream in this area having sufficient force to move, round off and grade such large

quantities of boulders. In the Lam Tsuen valley particularly the resemblance to glacial moraine is most marked. A possible explanation of the Tai Mo Shan boulder streams may be afforded by a theory of vegetation change and accelerated erosion. However, likely or unlikely that may be, it is apparent that weathered boulders and gravel washed into the Lam Tsuen valley to such an extent that drainage was completely disrupted and blockages occurred causing lakes to be formed. The most effective blockage spans the valley at Wai Tau and the dammed up water spilled over into the Tai Po valley.

In course of time, the boulder streams became less active and only the finer materials were carried down to fill up the lakes, and the Lam Tsuen stream cut a permanent outlet to Tai Po along the line of weakness at the junction of the Tai Po Granodiorite and an outlier of Pat Sin sediments.

The geomorphology of the Tai Hang portion of the region is much simpler to understand. Each of the streams which run into the valley from the mountains has deposited an alluvial fan of mixed gravelly sandy clay loam material. These fans have coalesced and form a continuous belt of Sun Hing Association soils around the periphery of the valley. In the centre of the valley a lacustrine alluvial

Association (Chik Nai Ping) has been deposited.

Traces of river alluvium may be found along the whole length of the Tai Hang section of this district indicating the course of the Lam Tsuen stream before it was diverted to flow out to Tai Po.

### Agricultural Pattern

The land utilisation of the Lam Tsuen/Tai Hang area closely follows the soil Association distribution. In the imperfect, poor and very poorly drained series of the Lam Tsuen Association two crops of paddy are grown and yields up to 400 catties per dau chung per crop may be obtained. On the freely drained series of the association however rice is not planted but there are Fung Shui groves with Lychee trees, and dry crops such as sweet potatoes and peanuts are grown. In the imperfect and poorly drained series of the Lam Tsuen association two crops of paddy yield up to 700 catties per dau chung per year (54 cwt/acre) which is above the general average for Hong Kong. It is rather surprising to find that the farmers in this very fertile valley are all Hakka. As a general rule the Cantonese villages are on the more fertile areas and the Hakka in the less productive hillfoot soils. It is probable that during the period of the Cantonese colonisation the Lam Tsuen valley was not a very desirable agricultural area



because of instability of the bouldery products of erosion and boulder dammed lakes or marshes.

When the lakes filled in and dried out, the alluvial deposits provided some of the richest land in the valley and all the vegetable farms are grouped on this soil. A small proportion of the vegetable farmers are immigrants but for the most part the Lam Tsuen valley has not suffered from the influx of refugees which has revolutionised the agriculture in adjacent areas at Tai Po and Fanling.

Where the Lam Tsuen Stream enters the sea at Tai Po, there is one of the largest of the vegetable areas. The soils are predominantly wet and poorly drained but Chinese Watercress is grown extensively through the year. Where the soils are slightly less poorly drained, flowers and Chinese vegetables such as Pak Choi are grown.

In the northern half of the area, the Tai Shui Hang Valley, the soils are quite different and rather less productive. In the middle of the Tai Shui Hang valley, on the Chik Nai Ping soils the farmers are mainly Cantonese but on the less productive Sun Hing soils many of the villages are Hakka. Only a small part of this valley section is planted to vegetables though there is an increasing tendency for immigrant farmers to settle alongside the road-side and the streams.

By far the largest vegetable growing area on the Lam Tsuen Tai Hang area is the Wo Hop Shep valley at the top of the map sheet. However this area more properly belongs to another district and is discussed in relation to the Fanling basin.

The Hong Lok Yuen orchard is one of the largest in the colony (115 acres) and is situated at the southern end of the Tai Shui Hang valley on bouldery material of the Sun Hing association. With such a sheltered position well drained soil and a good water supply the site is ideal for an orchard. The soil in the orchard is predominantly derived from Tai Mo Shan porphyries but there is an admixture of stony debris of Pat Sin sediments and this has resulted in the development of a slightly better soil structure and a slightly higher pH (7.2) than in the surrounding hill soils.

The statistical analysis of the cultivated land in the Lam Tsuen/Tai Shui Hang map sheet is given in Table VIb.

#### TUNG CHUNG (Figs 22a, 22b)

On the whole of Lantau Island there are only two agricultural areas of any appreciable size. The larger of these areas is at Tung Chung in north Lantau opposite the island of Chek Lap Kok. On either side of Tung Chung

TABLE VI (b)

THE SURVEY OF CULTIVATED LAND AT LAM TSEUN, TAI HANG AND TAI O. 1959.

Village	Paddy (2 crops)	Paddy (2 crops) & 1 Catch-crop	Vegetable	Orchard	Miso. Crops	Upland Paddy (1 crop)	Flower Crops	Total (Acres)
Pak Ngau Shek	13.54	-	2.53	3.57	1.04	-	-	20.68
- do -	56.67	-	19.40	0.13	0.59	-	-	76.79
Ping Long	22.87	-	6.07	-	0.04	-	-	28.98
Ma Po Mi	45.47	-	22.65	1.40	2.15	-	-	71.67
San Tong	71.44	-	36.67	1.29	1.21	6.93	-	117.54
Chung Uk Tsun	119.53	0.57	44.60	5.98	17.96	-	-	188.64
Tai Om	26.63	-	11.38	0.13	2.39	-	-	40.53
Hang Ha Po	30.30	7.64	28.70	-	1.28	-	-	67.92
Wai Tau	41.96	5.96	19.06	33.62	4.23	-	1.87	106.70
Tsoi Hang	123.20	2.33	8.72	3.81	1.08	-	-	139.14
Hong Lok Farm	-	-	-	115.80	-	-	-	115.80
Tai Po Tau	19.74	54.47	32.01	2.60	-	-	3.50	112.32
Tai Po	24.45	25.84	62.83	2.56	-	-	-	115.68
Lin Au	35.10	-	2.60	0.52	7.67	1.28	-	47.17
Lai Chi Shan	27.88	6.81	17.04	2.09	0.51	-	-	54.33
Un Iu	31.39	-	4.07	1.58	0.42	-	-	37.46
Nam Hang	-	-	7.20	-	-	-	-	7.20
Kau Lung Hang	86.29	-	16.85	3.09	0.88	-	-	107.11
Pai Wo	104.87	-	16.50	0.15	1.01	-	-	122.53
Po Hop Shek	16.52	-	158.04	-	-	-	-	174.56
Pun Shan Chau	34.92	2.09	2.04	-	0.80	0.76	-	40.61
Total	932.77	105.71	518.96	178.32	43.26	8.97	5.37	1793.36

Bay the encircling mountains extend to the shore where they form sea cliffs so that the valley is completely contained within mountains and sea. In shape Tung Chung depression resembles the letter 'M' with mountains forming the outline and the sea closing off the base of the figure.

Tung Chung appears to be completely cut off from other districts of Lantau by a ring of very steep mountains but there are a number of well defined pathways through the hills to Silvermine Bay, Shek Pik and Tai O. Most of the communication with the rest of the colony is by boat though silting up of Tung Chung Bay prevents vessels of greater than three feet draught from coming in to the shore. Comparatively few fishing boats are based on Tung Chung and the settlement is predominantly agricultural (Plate 15).

#### Drainage

Two streams bring a more than adequate supply of water to the valley. Fortunately these streams do not flow directly from the mountainsides on to the plain but approach the flat land through comparatively long and well graded valleys so that flooding caused by an abrupt change of slope is not a serious problem here as it is in the basins surrounding Deep Bay. Some of the tributary streams at the eastern side of the depression flow from eroded granite hills and occasionally carry large quantities of sand which



may cause slight flood damage, particularly around the village of Wong Nai Uk.

Geology & Geomorphology (Fig. 17)

Tung Chung lies at the focal point of a whole series of geological faults and the mountains round the depression belong to several geological formations. On either side of the Bay there are granite hills with very steep slopes ( $30^{\circ}$ ) and skeletal soils or bare rock. Behind Ma Wan Chung the granite is porphyritic with large phenocrysts of orthoclase which weather readily so that exposures of the rock often have a pitted or sponge like appearance. Neither the porphyritic granite nor the Hong Kong Granite on the western side of Tung Chung Bay is badly eroded but the island of Chek Lap Kok is very seriously denuded and gullied.

Adjacent to the porphyritic granite there is an exposure of the Repulse Bay Volcanic Formation with very sharp ridges devoid of vegetation and steep sided rocky valleys with sparse grasses. Numerous sills and dykes form low cliffs or crags on the valley sides. From the subsidiary valleys an apron of boulder fan material has been deposited. The most recent of these boulder fans has engulfed an old village (Tung Chung Hang) and has partially blocked the valley above Shan Ha.

The mountain behind Wang Ka Wai is of Tai Mo Shan

Porphyry and is a spur of the Tai Yu Shan ridge which forms the spine of Lantau. Normally, soils formed on this rock formation are not particularly susceptible to erosion, but there has been severe shattering of the rock, particularly on the Western side of the spur, and though the slopes are not unduly steep, gullying occurs on the ridges and sheet erosion is beginning to be a serious problem.

There are remains of extensive terracing in the main valley above Shek Mun Kap and the main reason for abandoning this easily irrigated land is the frequent engulfing of the fields by surface wash from the slopes above. Afforestation of these slopes would undoubtedly lead to expansion of the arable area in this district.

Around Shek Mun Kap and Mok Ka, faulting and shattering has provided a mass of bouldery material which is deposited in the whole of the western side of Tung Chung depression.

The lines of the main faults may be seen from the block diagram (fig. 17) but it should be emphasised that this represents only the more important dislocations, and ignores, for the sake of clarity, the large number of subsidiary cleavage lines, dykes, sills and shatter zones.

Tung Chung obviously lies at the point of weakness where all these faults intersected. For the most part the depression was filled up by boulder fan material but, in

common with many of the other lowlying valleys in Hong Kong (Shek Pik, So Kung Wat, Sai Kung), a sand bar built up by sea currents closed off the bay, and the lagoon behind filled up with lacustrine sediment.

### Soils

The soils and land use very clearly reflect the geomorphology of the area. At the shore there is a broad belt of sandy soil developed on sand dunes which may be clearly identified as a former offshore bar with complex spits and loops.

Behind the sand bar lacustrine/lagoonal material has formed soils of the Chik Nai Ping Association.

The greater part of the rest of the depression is filled with boulder fan material derived from Tai Mo Shan Porphyry and rocks of the Repulse Bay volcanic Formation forming Sek Kong Association soils. These bouldery materials underlie most of the Chik Nai Ping Soils and affect the soil drainage. Most of the stones are of moderate size (up to 1' in diameter) but near the villages of Mok Ka and Shek Pik Au there are boulders more than 6' diam. which are a hindrance to cultivation.

Shatin Association soils are found in the north-eastern segment of the depression but the materials are illsorted and highly acid so they are of little agricultural value though there is a good supply of water.

Agricultural Pattern.

Tung Chung is more interesting for its potential rather than for its present agricultural value. Owing to its relative inaccessibility only those crops which can withstand delays in transportation <sup>are?</sup> can be grown. There is a growing realisation among the farmers, that greater benefits derive from vegetable cultivation than from rice growing. An increasing acreage is planted to shallots every winter and the high price, low bulk, moderately robust vegetable is well suited to the particular requirements of Tung Chung. The soils are mainly well drained, well irrigated and somewhat sandy so that they are more suitable for vegetables than for rice.

A new pier is planned and a channel is being dredged so that cargo boats and ferries may come into Tung Chung and it will be very interesting to compare the agricultural pattern in a few years time with the present crop map. Almost certainly there will be radical changes; many of the fields that grow a below average ( 250 catties) crop of rice will turn to vegetables and there will probably be some relocation of population with farmhouse, rather than village communities. At the moment there are very few immigrant farmers and it will be instructive to discover whether the local Cantonese farmers will be able to fully utilise all their land for vegetables.



The yield on the Chik Nai Ping Soils in Tung Chung (250-300 catties/dau chung) is low for this Association but if more winter vegetables are grown and more money made available for fertiliser it is anticipated that the productivity of the soils will be raised considerably.

On the sand dune soils and in some of the free to imperfect series of the Sek Kong soils sweet potatoes and a small amount of peanuts are grown. The peanuts are largely for local consumption but the sweet potatoes are fed mainly to pigs. There are increasing numbers of pigs in Tung Chung. A large area of soils is suitable for sweet potato cultivation so an increase in pig breeding may be anticipated if marketing can be organised.

On the Western side of the depression the hillsides have an adequate water supply and the soils are well drained and suitable for fruit trees or pineapples.

No rainfall statistics are available for Tung Chung but from personal observation the area is very frequently the centre for very intense thunderstorms which are often contained within the depression. It may well be that Tung Chung may be able to specialise in some such vegetable as cabbage or lettuce which require a great deal of moisture or that because of the cloud cover the season for tomatoes or other European vegetables may be extended.

TABLE VI (c)

THE SURVEY OF CULTIVATED LAND AT TUNG CHUNG 1952.

Village	Paddy (2 Crops)	Paddy (2 crops) & 1 Catch-crop	Vegetable	Orchard	Miso. Crops	Up Land Paddy (1 Crop)	Flower Crops	Total (Acre)
Sha Tau Tau	14.00	-	1.20	-	-	-	-	15.20
Mak Ka	106.00	-	1.80	-	5.73	-	-	113.53
Shek Lau Po	5.64	-	0.16	-	0.55	-	-	6.35
Sheung Ling Pei	30.73	60.27	3.91	2.00	11.91	-	-	108.82
Tai Po	16.37	-	-	-	0.36	-	-	16.73
Tung Chung Hang	13.54	-	0.21	-	1.06	-	-	14.81
Total	206.66	60.27	7.28	2.00	19.61	-	-	295.82

It is rather difficult to comment on the agricultural pattern in this area. The land use must be assessed on what it could be rather than what it is. More than any other area, Tung Chung will repay study, in observing the changing agricultural economy of Hong Kong.

#### MUI WOH or SILVERMINE BAY (Figs. 23a, 23b)

It is useful and instructive to compare Mui Wo with Tung Chung. Both these districts are on Lantau Island but whereas the latter is isolated and inaccessible, the former is well supplied with ferries to Hong Kong and is linked to the whole of South Lantau by road. As a result of its good communications and despite its poor soil, Silvermine Bay has an agricultural importance disproportionate to its area.

The Mui Wo district lies at the end of a well protected bay in southeastern Lantau but there are few fishing boats based here. Formerly silver was worked in the hills behind Mui Wo but the quality of the ore is low and the occupations in the valley are predominantly agricultural (Plate 14).

#### Geology and Geomorphology

As in the case of Tung Chung a sand dune between two headlands has closed off the valley forming a lagoon

and permitting lacustrine materials to be deposited. The surrounding hills are mostly formed of porphyritic granite though there are numerous veins of pegmatite and numerous intrusions of quartz. The Lantau granite is much less seriously gullied than the Hong Kong Granite round Tai Lam Chung and Castle Peak. The reasons for the relative absence of gullying in northeastern Lantau may be partly mineralogical and climatic, but may also be related to the low population density in the porphyritic granite areas. Erosion is notably more severe around Mui Wo than it is in the geologically identical hills at the eastern tip of Lantau. One consequence of this erosion is the tendency for flooding and silting up of fields close to the hills.

The hills to the south of the depression are partly Tai Mo Shan porphyries and the difference in geology is strikingly noticeable in the vegetation and general appearance of the hills. Behind Lung Ti Tong village the hillside is well wooded and the slopes are smooth though steep, whereas the area north and east of Mui Wo village is covered with sparse grasses and the ridges are bare and gullied.

### Soils

Most of the soils are comparatively thin, very acid, and stony, but in the southern part of the depression there is a small extent of Chik Nai Ping soils which are moderately



productive. Part of this area in the south is only recently reclaimed from the sea and the soil is slightly saline ( 4,000 p.p.m.NaCl.) but there is adequate fresh irrigation water for two crops to be grown and yields of 250-280 catties per d.c. ( $1\frac{1}{2}$  tons/acre/year) may be obtained. The granitic hillfoot soils of the Shatin Association yield only 150 catties per d.c. and some fields have been noted with yields as low as 100 catties. Many of these granitic soils would respond well to fertiliser, particularly nitrogenous, and some quite spectacular yields have been noted where the rice benefited from the residual fertiliser of a winter crop of vegetables.

#### Agricultural pattern

Mui Wo is well supplied with markets for its produce and there are excellent facilities to transport the goods to those markets. A frequent ferry service carrying both passengers and cargo runs to Hong Kong and to Cheung Chau so that vegetables can be despatched from Silvermine Bay with the minimum handling or delay. Vegetables are grown throughout the area and give a much better return than rice on these sandy soils. There is plenty of irrigation water throughout the year, dry crops such as peanuts and sweet potatoes are not grown to any extent but large quantities of European type vegetables

TABLE VI (d)

THE SURVEY OF CULTIVATED LAND AT MUI WO 1959.

Village	Paddy (2 crops)	Paddy (2 crops) & 1 Catch-crop	Vegetable	Orchard	Misc Crops	Up land Paddy (1 crop)	Flower Crops	Total (Acre)
Pak Ngsu Heung	38.88	-	22.85	2.90	2.53	-	-	67.24
Mong Tong	19.22	7.44	17.96	-	1.00	-	-	45.62
---	2.13	-	1.65	2.74	1.78	-	-	8.30
Lung Ti Tong	14.58	-	32.13	1.39	1.34	-	-	49.44
Teang Hau	4.47	25.63	20.63	5.21	-	-	-	55.94
Total	79.28	33.07	95.22	12.32	6.65	-	-	226.54

(lettuce, cabbage, cauliflower) are grown in the winter and Chinese vegetables in the summer months.

It is anticipated that an increasing acreage in this district will be planted to vegetables and that in a few years time little or no paddy will be grown except on the richer Chik Nai Ping soils where a winter catch crop is also grown.

There is only one orchard of any appreciable size, opposite the village of Lung Ti Tong but the soils on the north and west facing hillslopes are suitable for fruit trees (guava, wong pei, tangerine) and pineapples do particularly well. All of the hill-slopes below the 50 metre contour line could be terraced for orchards but large quantities of potash and some phosphate fertiliser would be required.

#### CASTLE PEAK-PING SHAN (Figs. 21a, 21b)

The granite hills of Castle Peak and Tai Lam Chung are the most barren and uninviting areas of the Colony, yet between them lies a fertile valley up to a mile wide and over three miles long. The Castle Peak-Ping Shan district is a corridor rather than a valley and is in fact an extension of the Deep Bay depression. There is a great variety in soils and agriculture in this district but the farms are not quite so productive as those of either the

Yuen Long or Kam Tin districts.

### Geology

In many ways the Castle Peak-Ping Shan area resembles a rift valley in miniature. There appear to be two parallel faults but the one on the west is more clearly marked than the one to the east of the depression. Between these faults lie metamorphosed sediments of the Lok Ma Chau formation.

The granitic hills have little effect on the soils or agriculture but there are a number of small quarries for quartz and the scars of former wolfram mines may be seen. Several long parallel fault line valleys penetrate the Tai Lam Chung mass in a NNW-SSE direction and these have been dammed to provide domestic and irrigation water for the Ping Shan and Yuen Long area. It is possible that similar valleys in the Castle Peak peninsula may be utilised to irrigate part of the area between Ha Tsuen and Ping Shan.

The mantle of recent alluvium on the Castle Peak-Ping Shan corridor is very thin and most of the villages are built on low hills of Lok Ma Chau material. For the most part these metamorphosed sediments have weathered deeply but where the rock is exposed it shows considerable variety from fine talc schist near the roadside at Tuen Mun San Hui, to coarse gneiss on the flanks of Castle Peak.



### Geomorphology

Within historical times, ships were able to sail from Castle Peak Bay to Yuen Long and the Castle Peak Peninsula was an island. Though the area is one of recent emergence there is no great depth of recent alluvium and there are a number of small mounds or hills of in situ soil. The process of emergence is quite recent and up to 500 years ago (Barnett, 1959) the inlet extended for almost 3 miles as far as Shek Po Tsuen and was up to  $\frac{1}{2}$  mile wide in places. Unlike other recently emerged land in the Colony (So Kun Wat, Tung Chung), Castle Peak corridor does not appear to have been built up as a lagoon behind a sandbar. The alluvial fans from the mountains on either side, have gradually extended until they merged so that there are only a few very narrow and discontinuous extents of lacustrine material. The process is still going on and the mudflats in Castle Peak Bay are extending rapidly. Some of the fields up to a mile inland from the sea are still slightly saline but this does not have a serious effect on the crops and there is very little brackish water paddy grown in this district. The last part of the district to dry out was a narrow swamp up to 500 yards long and 300 yards wide aligned along the depression near the village of Tsing Chuen Wai. The swamp drained indeterminately either to the North through the Ha Tsuen-Ping Shan area or south to

Castle Peak Bay.

### Soils

The soil pattern of this district is very complex but may be readily understood in relation to the geomorphology (Plate 11).

Where the underlying Lok Ma Chau sediments are near the surface they give rise to the Castle Peak Association comprising a thin veneer of alluvium over an 'in situ' material which is red except in the most poorly drained situations. Around San Wai Tsai and the new government mental hospital at Castle Peak the small hills of bright red material are quarried for brickmaking and the soil is lateritic with occasional occurrence of pisolitic gravel. Elsewhere in the district these low hills form village sites and are occasionally cultivated for dry land crops or fruit trees.

Extending out from the mountains and lapping up against the in situ material there are large spreads of fan material which is sometimes stony, but is normally an illsorted sandy clay and is never bouldery. This material forms two associations. Where it is very sandy and predominantly derived from granite it forms series of the Shatin Association but where the material has a fairly high proportion of clay and is reddish coloured, Sun Hing soils

are formed. Both Shatin and Sun Hing soils are moderately productive in this area because they occur mainly in the narrower, well watered southern half of the depression.

North and west of Tin Sam and Ping Shan there is inadequate water and though the soils are moderately good, rice yields tend to be low. In this northern half of the district there are Mai Po, Fanling and Chik Nai Ping soils associated with the Deep Bay Complex, but the centre of the depression is still occupied by Castle Peak soils.

The soil pattern may be resolved into a low ridge of in situ material running the full length of the depression, flanked by Alluvial fans of granite, mixed, and of Lok Ma Chau sediment derivation, with small extents of lake or marsh soil filling up the hollows between the alluvial fans and the in situ ridge.

### Agriculture

From the Land Use map (fig. 21a) it is at once apparent that there are two separate and <sup>distinct</sup> ~~district~~ agricultural centres, one at the southern end of the district and the other to the north around Ping Shan. These are areas of more intense and diversified <sup>2</sup>forming than that in the middle of the depression round Shun Fung Wai or to the north in the Ha Tsuen area. The reasons for differentiation are partly pedological and partly social. Intensive

vegetable <sup>a</sup>forming is a fairly recent development in the Colony and seems to spread around particular settlement or marketing areas. The main road runs the length of the depression so that all areas have equal communication facilities but at San Hui a variety of factors have encouraged settlement (a) Good road and sea communications

(b) Available land for rent

(c) Plentiful water supply and good soil

(d) Proximity of nightsoil supply (Tanks built at Castle Peak during the Japanese occupation)

(e) Large and important market at San Hui.

Around Ping Shan slightly different factors are operative. The soils are good but drier than at Tuen Moon San Hui. Much of the land, which is now intensively cultivated there, was not suitable for paddy and the local villagers readily sold or rented land to immigrants who proceeded to grow sugar cane on the drier land and water chestnuts or vegetables where the soil is wetter. Water Chestnut is particularly susceptible to salinity and this area around Ping Shan is free from salt.

In the Ha Tsuen area to the north of the map Sheet many of the fields are too saline to permit winter vegetables to be grown but the soils are quite good and



TABLE VI (c)

THE SURVEY OF CULTIVATED LAND AT CASTLE PEAK-PING SHAN 1959. (Area in Acres)

Village	Paddy (2 crops)	Paddy (2 crops) & 1 Catch-crop	Vegetable	Orchard	Misc. Crops	Upland Paddy (1 crop)	Flower Crops	Total
Castle Peak	10.08	18.56	8.28	1.88	2.24			41.04
Yeung Siu Hang	9.00	24.44	33.84	19.32	2.24			88.84
Tsz Tin Tsun	83.76	170.52	61.36	39.92	11.72			367.28
Shung Fung Wai	59.20	289.56	72.52	32.72	22.88			476.88
Tin Sam	174.64	333.36	61.74	27.52	36.20			633.46
Hung Uk Tsun	9.20	17.04	3.96	5.24	12.68			48.12
Fui She Wai	54.16	72.88	12.24	9.36	44.08			192.72
Ping Shan	3.64	2.04	14.24	1.88				21.80
Ha Tsun	107.76	132.32		2.20	2.68			244.96
Grand Total	511.44	1060.72	268.18	140.04	134.72			2115.10

two crops of rice are obtained though the yield is only moderate. Where the salinity is slightly less, as in the Central part of the district around Shun Fung Wai, higher yields of rice are obtained and salt resistant vegetables such as tomatoes are grown as a catch crop.

Agricultural development in this area will probably centre around the extension of the area on which winter vegetables can be grown but it is unlikely that there will be a spectacular changeover from rice to vegetables because the soils are not suitable and water supply is inadequate. Nevertheless it is probable that there will be some extension of vegetable farming in a narrow strip along the roadside and the streams.

#### YUEN LONG (Figs 25a, 25b)

The town of Yuen Long lies at the centre of a very rich and varied agricultural area, and is the largest market town in the New Territories with a population of 16,800. The district is predominantly rice growing and in spite of good soil and adequate communications there is a comparatively limited extent of vegetable farmland. With the exception of one or two Hakka villages near the hills and two communities of immigrants around Ping Shan and Yuen Long, most of the farmers are Cantonese.

### Drainage

Extensive marshes and mudflats occur in the north of the district and the whole area is very lowlying and subject to flooding. The greater part of the area is drained by the Yuen Long Creek which is tidal as far inland as Yuen Long San Hui. There is a small extent of brackish water paddy around Yuen Long and a much larger extent to the northwest of Yuen Long. Within the past 500 years Yuen Long was a sea port with access by way of Castle Peak and Ping Shan but extensive deposition and reclamation has taken place around Deep Bay. The most recent reclamation was completed about 40 years ago when a private company built a sea wall and a system of sluice gates across the western part of Deep Bay at the mouth of the Ping Shan creek. By this reclamation more than 800 acres of paddy land were gained and though the greater part is suitable only for brackish water paddy, the salinity is decreasing and the area of fresh water is gradually extending (Plate 12).

### Geology

With the exception of two small inliers of Lok Ma Chau metamorphosed sediments near Tai Tong, all of the hills to the south of the area are granitic. The line of hills which separates Yuen Long from Kam Tin is formed of Tai Mo Shan Porphyry and the small hills or 'islands' which stick

up through the alluvial materials are mainly schists of the Lok Ma Chau formation.

### Soils

The granite hills to the south are severely eroded and all of the soils in the triangle south of San Tsuen belong to the Sha Tin Association and are developed on granitic alluvium. Extending eastward from Ping Shan and just south of Yuen Long there is a belt of 'in situ' material which constricted the outlet of the streams flowing from the granite hills so that a lake formed in the area between Ma Tin Tsuen and San Tsuen. The lacustrine materials deposited here have developed into soils of the Chik Nai Ping association. To the north of the natural breakwater formed by the in situ material, more recent lagoonal soils of the Mai Po Association are formed round the Deep Bay marshes (Plate 9).

### Agricultural Pattern

The land use pattern is very simple and straightforward. On the drier soils of the foothills the usual dryland crops such as sugar cane, sweet potatoes and ground-nuts are grown but in the well watered soils of the basin there are paddy fields with a winter catch crop of vegetables (mainly tomatoes). Around Ping Shan and Yuen



Long there are rapidly expanding communities of vegetable farmers. On the more recent alluvial soils near the Ping Shan and Yuen Long creeks the soils are too saline to grow a catch crop in the paddy fields and the quality of the brackish water paddy is very low. Though yields of up to 400 catties per dau chung may be obtained in the brackish water areas only one crop per year is possible and the rice fetches only \$30 per picul as compared with \$45 per picul of fresh water rice. A certain amount of additional income may be obtained from the brackish water paddy fields by the trapping of mud skippers or walking goby (*Boleophthalmus sinensis*). These mud skippers are also caught in the mangrove swamps and the Tembaks (Satwater fish ponds filled by the tide and controlled by sluice gates). Each Tembak is a large field surrounded by a bund up to 10 feet high. The sea is allowed to enter at high tide and the sluice gates are then closed so as to permit a portion of the water to escape but fish (30%) and shrimps (70%) are trapped and caught. There are 2000 acres of Tembaks in the Deep Bay area. The process of allowing the silt-laden tide to enter, allowing the water to run out slowly, gradually accumulates an appreciable depth of fine 'warp' soil. Thus the tembaks act as a form of land reclamation similar to the process of warping by means of which soils are built up along the estuaries of Lincolnshire (Whittles, 1928). Areas

which are insufficiently tidal to be suitable for tembaks but are too saline for brackish water paddy, are utilised for cultivation of sea grass which is used in the manufacture of grass or 'straw' matting.

The marshland around Deep Bay is gradually being reclaimed naturally and by the Tembaks but the process could be speeded up and a large area made available to agriculture if a system of bunds could be built and a series of water gates devised to permit egress of drainage water from the rivers but preventing the tide from flooding the land. One of the main problems facing such reclamation is the difficulty of controlling these watergates in time of flood if the high tide and high floodwaters coincide.

#### FANLING - TA KU LING (Figs. 24a, 24b)

The twin basins of Fanling and Ta Ku Ling contain some of the most intensively cultivated land in the world, with a very high density of agricultural population. The two main towns Fanling and Sheung Shui are expanding rapidly but the greater part of the people are evenly distributed over the farmland, each family living, both in the physical and in the financial sense, on smallholdings about one third of an acre in area (Plate 13).

#### Drainage

Although they are up to five miles from the sea,

TABLE VI (f)

THE SURVEY OF CULTIVATED LAND OF YUEN LONG 1952.

Village	Paddy (2 crops)	Paddy (2 crops) & 1 catch-crop	Vegetable	Orchard	Misc. Crops	Brackish water paddy (1 crop/yr.)	Flower Crops	Total(Acres)
Shan Pui	59.08	8.96	16.96	25.32	4.24	38.72	-	153.28
Hung Tso Tin	35.48	540.00	6.04	4.40	27.24	-	-	613.16
Nam Hang	49.92	114.44	11.60	-	90.80	-	-	266.76
Tai Tong	34.52	161.08	29.36	2.40	81.96	-	-	309.32
Pak Sha	31.16	255.16	-	6.44	112.56	-	-	405.32
Shan Ha	43.76	176.96	65.84	51.20	52.72	-	-	390.48
Ma Tin	62.16	294.52	72.32	13.88	11.28	6.56	-	460.72
Ping Shan	30.40	71.96	49.84	34.48	48.96	-	-	235.64
Wang Chau	78.52	113.64	6.32	4.32	17.12	-	-	219.92
Wang Chau	75.72	19.96	0.32	4.84	43.12	25.28	-	169.24
Kiu Tau Wai	36.80	68.16	15.84	20.96	50.72	192.48 661.00	-	1045.96
Total	537.52	1824.84	274.44	168.24	540.72	924.04	-	4269.80

both basins are very lowlying and subject to flooding when a heavy rainfall coincides with a high tide. The Shum Chun river is tidal almost as far inland as Ta Ku Ling and brackish water paddy is grown alongside the river at Lowu. The Sheung Shui-Fanling basin is well supplied with water by two streams fed from an extensive catchment area which stretches north to the Robins Nest near Sha Tau Kok and east to the Pat Sin Range in Sha Tau Kok peninsula. There is considerable evidence to suggest that the main stream flowing into the Fanling area from the north east, has captured the headwaters of the Takuling Basin drainage system. From the productivity map (fig. 24b) it may be noted that yield of rice is very much lower in the Takuling than in the Fanling basin and this difference is largely due to the inadequate water supply of the Ta Ku Ling area. Both basins drain into the Shum Chun river which marks the boundary between Hong Kong and China.

### Geology

All of the hills which surround the basins are formed of rocks of the Tai Mo Shan Porphyry formation, with the exception of a line of low hills along the border, which are formed of Lok Ma Chau metamorphosed sediments.

The NE - SW fault system is less in evidence in this area than in most of the other agricultural districts



but the belt of agricultural land along the Fanling-Sha Tau Kok road which links the two basins lies along the faultline which extends from Sha Tau Kok through Fanling to the Kam Tin basin and Tai Lam Chung. The junction between the Lok Ma Chau schists and the Tai Mo Shan porphyries though parallel to the Sha Tau Kok fault, is less well defined, and is comprised of a series of minor slips, dykes, and lines of weakness which may be noted along the Sheung Shui-Ta Ku Ling road and along the Shum Chun river between Lowu and Man Kam To, and at Ta Ku Ling.

#### Geomorphology (Fig. 18)

Both of the alluvial basins have had a parallel, and very recent, history of emergence from the sea. The very narrow gaps at Lo Wu and at Ta Ku Ling are the only outlets for water from an agricultural area of 3,500 acres with a catchment of 27.8 square miles, consequently severe flooding is frequent particularly between Sheung Shui and Lo Wu. It is apparent that a lake must have occupied the lower part of the Fanling basin until very recently, and both basins must have been at least partly lagoonal within the last 1500 years. A rise in sea level of less than twenty feet would submerge the greater part of both basins, but in view of the narrowness of the outlets and the general lack of saline features in the soils it is probable that the lakes or lagoons were fresh water or only slightly

saline.

In the process of emergence there was a period of indeterminate drainage in the linking valley at the head of the two basins and swampy conditions prevailed. Relics of the swamp may be seen in the black soils of the Fanling Association which stretch in a flattened arc from Sheung Shui through Fanling and along the line of the River Indus to Ping Che in the Ta Ku Ling basin. Eventually drainage to the Fanling basin gained dominance and the Indus captured the head-waters of the Ta Ku Ling stream.

### Soils

The soil pattern in this area is more complex than in any other part of Hong Kong but the same sequence of colluvial (Sun Hing), 'in situ' (Castle Peak), and lagoonal (Chik Nai Ping or Mai Po) soils, is present but there is a complication due to the large extent of soils of the Fanling Association. These black soils are not limited solely to the areas mapped as Fanling Association but occur also as persistent horizons of various thickness in the subsoil of Chik Nai Ping, Mai Po, and Sun Hing soils in the Sheung Shui-Fanling-Ping Che area. It has not been possible to map specifically, the black soil horizons in other associations, because of the complexity of the resultant map. It is recommended that further research be carried

out on the nature of the Fanling soil and its relationship to the distribution of vegetable farming.

### Agricultural Pattern

The land use map (Fig. 24a) is dominated by the large patch of yellow representing the vegetable growing area. More than 800 acres are devoted to permanent, intensive vegetable farming with 12,000 people settled in temporary structures which have arisen over the past five or six years. The area under vegetables is still expanding but at a less rapid pace than formerly. The majority of farmers engaged in this type of farming are immigrants but there is a growing tendency for local Cantonese and Hakka villages to abandon the traditional rice economy in favour of the more lucrative vegetable farming. The connection between the Fanling soils and distribution of vegetable farming has already been noted but it should be emphasised that social factors are equally important. When the first few immigrants came to the Fanling district they settled not because of the soil but because in no other comparable district of the New Territories were they able to rent paddy land with adequate communications and water supply for their purposes. Other suitable areas exist, e.g. in Kam Tin and Yuen Long, but the strong clan system of land ownership based on tradition and convention

would not permit sale or rent of land to outsiders. It is not the purpose of this report to investigate the motives that guided the villagers of the Fanling district in breaking with tradition before the rest of the farmers of the Colony but it may be noted that even the most conservative of the other districts are following suit. Having found a foothold in Fanling the immigrants rapidly prospered under a favourable disposition of soil, climate, water, market and communications, so that they were encouraged to invite their friends and compatriots to join them. Thus there are complete communities from specific localities in China forming enclaves within the vegetable farming district.

All of the farmers are agreed that the black material of Fanling Association is beneficial to vegetable farming but only as a subsoil, or as a top dressing on other soils. In the Ping Che area where the soil is black and heavy textured up to the surface, rice yields are low and vegetable cultivation is not progressing very successfully.

The Ta Ku Ling basin as a whole is much less prosperous than the Fanling basin because of lack of water. Both areas grow two crops of rice but only in the paddy areas round Sheung Shui and Fanling is it possible to grow a winter catch crop. The soils of the Ta Ku Ling area are moderately good and it is certain that productivity could



be very greatly increased if the irrigation water supply could be improved. It should be possible to divert at least some of the headwaters of the 'Indus' River to flow into Ta Ku Ling basin.

In the area around Lo Wu, yields are low because the fields tend to be waterlogged, and flooding is frequently serious. Flood control is difficult because of the narrow gap at Lo Wu but if the headwaters of the Indus were diverted to Ta Ku Ling as suggested above, both basins would benefit.

Future changes in land use will depend on irrigation and drainage control but it may be confidently forecast that the area under rice will be reduced and vegetable farming extended westward along the San Tin road and southward alongside the golf course. It may be that careful irrigation and scientific application of fertiliser may assist in extending vegetable cultivation into the Ta Ku Ling basin.

#### SHATIN (Figs. 26a, 26b)

There are only 852 acres of agricultural land in the Sha Tin district yet there are a great variety of crops grown. Because it is close to Kowloon and is very well served by both road and rail communications there is a large proportion of land devoted to vegetables, flowers

TABLE VI (g)  
THE SURVEY OF CULTIVATED LAND AT TAN LING--TA KU LING 1952. (Area in Acres).

Village	Paddy (2 crops)	Paddy (2 crops) & 1 Catch-crop	Vegetable	Orchard	Misc. Crops	Up land Paddy (1 crop)	Flower Crops	Total
So Kon Po	43.60	120.16	160.84	-	4.00	-	-	328.60
Fan Ling	86.16	3.16	194.78	32.60	-	-	-	316.72
Sheung Shui Wai	208.45	-	15.83	2.00	23.88	-	-	250.16
Son Uk Tsai	94.78	85.96	107.62	-	27.28	-	-	315.64
Ping Kong	180.48	-	0.52	-	19.52	-	-	200.52
Tsung Pak Long	144.24	-	7.48	-	11.84	-	-	163.56
Ho Sheung Heung	344.73	-	37.11	-	15.04	-	-	396.88
Muk Wu	166.56	-	.84	-	94.64	-	-	261.84
Shan Kai Wat	166.88	-	-	-	28.80	-	-	195.68
Kan Tau Wai	230.92	-	-	-	59.96	-	-	290.88
Nga Iu Ha	66.80	-	-	-	26.56	-	-	93.36
Ping Yeung	94.44	-	-	-	28.40	-	-	122.84
Pang Che	110.04	-	-	-	20.82	-	-	130.86
San Wai	25.00	-	223.92	-	-	-	-	248.92
Kwan Tei	97.92	-	90.40	2.36	15.20	-	-	205.88
Grand Total	2060.82	209.28	839.34	36.96	375.94	-	-	3522.34

and orchards, though the soils are not very good and much of the land is subject to severe flooding. It is unlikely that Sha Tin will survive long as an agricultural area. Already a considerable number of factories and houses have been built. Proximity to Kowloon and an ample water supply are the features which favour farming and unfortunately these are also the features which attract industry to the Shatin valley. Furthermore the beautiful setting of the valley has made it a popular residential area (Plate 10).

At first sight Sha Tin resembles the typical U valley or fiord of a glaciated region with its steep mountainous sides and wide flat bottom, but closer inspection reveals that it is another fault line valley with the NE - SW alignment typical of the S.E. China Mountain Complex.

### Geology

All of the surrounding mountains are granite but with a sheltered northern aspect so that there is little active gullying though a large proportion of the hillsides on the eastern side of the valley are bare and skeletal. During the Korean war period Wolfram was mined but the deposits were small and the workings have been abandoned. There are numerous small quarries for quartz and feldspar, and small veins of galena have been found. Iron is mined at Ma On Shan which lies to the North east of the Shatin Valley.

### Geomorphology

Though there is a large area of shallows in Tide Cove it is evident that they indicate recent submergence of the area. Village traditions (Barnett, 1959) place the coastline of 500 years ago much further northward so that the whole of the area shown as sea in the land use map (Fig. 26a) must have been dry land. Further submergence is also reported from Tai Po and Plover Cove so that there is some support for the theory that the whole colony may be tilting about a NE-SW axis.

A small area was won back from the sea by Imperial Edict under the old corvee system of China at To Shek near Sha Tin Wai. The process has not been extended though it would appear to be a simple matter to build other sea walls to the west or to the north east of the Yen Chau Kok peninsula.

In spite of the steepness of the hill sides the soils which fill the valley bottom are almost entirely alluvial and there is only very small extents, of colluvial soil though many of the tributary valleys are filled by bouldery material.

The whole area is subject to severe flood damage because of the comparatively large number of mountain torrents which flow into the valley. In the productivity



TABLE VI (h)

THE SURVEY OF CULTIVATED LAND AT SHAT, 1959. (Area in acres)

Village	Paddy (2 crops)	Paddy (2 crops) & 1 catch-crop)	Vegetable	Orchard	Misc. Crops	Tung Oil Plantation	Brackish Water Paddy	Flower Crop	Upland Paddy (1 Crop)	Total
Sheung Kang Hau	0.41	10.06	15.97	10.52	1.25	145.00				183.21
Kak Tin	11.88	10.80	1.06	13.46	3.03					40.23
Tin Sam	40.50	23.48	33.67	11.00	1.25			5.75		115.65
Tai Wai	15.64	0.61	13.42	0.67	3.02			2.38		35.74
Che Kung Miu (Temple)	6.46	17.40	26.89	2.74	0.50					53.99
(A)Heung Fan Liu	2.39	2.91	11.69	5.42	2.07			0.22		24.70
(B)Heung Fan Liu	0.96	2.33	25.05	2.92	2.72					33.98
Tin Liu	1.43	13.89	7.68		5.35			0.33		28.68
Pai Tau Wai	2.66	4.48	6.31	1.65	2.04			2.22		19.36
Po Tan	11.83	13.86	13.99	0.89	1.00			2.62		44.19
Ho Lek Pui	4.04	4.04			2.12			2.78		10.20
Lok Lo Ha	0.28	0.61	1.06		4.18					8.91
Tsang Tai Uk	46.70	3.32	6.97	1.24	1.10					59.33
Sha Tin Wai	57.09	12.46	7.17	0.24	2.78		6.61	6.61		92.96
Wong Nai Tau	20.17	23.86	2.10	0.84	2.08		1.20			50.25
Shek Ku Lung	26.89	13.85			4.05				6.16	50.95
Total	255.49	157.96	173.03	51.59	38.54	145.00	7.81	22.91	6.16	852.33

map (fig. 26b) the three dotted areas (a) alongside the Shing Moon river above Tung Lo Wai (b) along the Sha Tin stream between Hin Tin and Tin Sam and (c) at the mouth of the main stream at Sha Tin, represent the areas which were completely destroyed for agriculture by sand and silt deposited in the 1959 floods. Rehabilitation of this land is almost impossible but an integrated flood control project has begun and the land may be used for industry or housing.

#### Agricultural Pattern

All of the soils belong to the Shatin association, the poorly drained and very poorly drained series predominating. Rice is grown mainly on the coarse sandy soils along the southern coastline of Tide cove and higher yields are obtained in the sandy loam soils around Tin Sam.

Only a small acreage of rice is grown in the Shing Moon valley and in the upper part of the Shatin valley. Most of the land is planted to vegetables, flowers and miscellaneous crops. The Shatin Association poorly drained series appear to be very suitable for cultivation of Chinese vegetables in the summer and European vegetables in the winter. Along-side the streams and on the soils of the very poorly drained series ginger flower is grown but on the imperfectly drained series the more conventional

flowers such as gladioli and chrysanthemums are grown. Around the periphery of the valley and where the soils are freely drained, taro, sweet potatoes and ground nuts may be planted and very poor crops of upland rice are occasionally grown. There are several small orchards on the lower slopes of the hillsides but they are all very recently established and do not yet enter into the economy of the district.

At the head of the valley a large plantation (145 acres) of Tung Oil trees was planted in 1957 but though the trees are flourishing no attempt has been made to extract commercial quantities of oil.

## CHAPTER VII

### AGRICULTURE.

There is an insatiable hunger for land, not only in Hong Kong and Kowloon for building sites, but also in the New Territories for agriculture. In spite of a vastly increased rural population and a deplorable fragmentation of holdings, there are more than 3,000 acres of abandoned land in the Colony. The explanation of this paradox lies in the changing standards of <sup>l</sup>iving and the specialised needs of present day intensive agriculture. Whereas in former times the local farmer grew only rice and established a certain self sufficiency in his economy, the modern farmers depend almost entirely on cash crops, and their livelihood is particularly sensitive to market changes both in the Colony and in the world at large.

Until the 1930s the farmers of Hong Kong were virtually unaffected by the city mushrooming on their doorstep. Hardly any of the food for the urban population was produced by the New Territories. The rural population in 1931 amounted to 98,156 and the main crop was rice. Though the rice grown was a negligible quantity in relation to the



needs of the Colony, it was of particularly high quality and was largely exported to the United States, while the main needs of Hong Kong were met by the import of rice of average quality produced in Indo China and Siam.

In postwar years the population of the Colony rose from less than 600,000 in 1947 to nearly 3 million in 1959. Much has been written on the causes and effects of this increase on the Kowloon-Hong Kong conurbation but it is seldom appreciated how much the growth of the city and the influx of refugees has revolutionised farming and life in the New Territories.

In the immediate post war years the city was booming and many of the marginal farmers left the land for work in town, but between 1948 and 1950 there was a flood of refugees from China. Many of these refugees who had been farmers in China settled not in squatter camps in the city but on any available land in the suburbs and in the New Territories. The enlarged population created a demand for vegetables which the immigrant farmers were able to satisfy by the intensive cultivation of small areas. Most of the immigrants have settled in distinct groups with a strong regional bias, thus all the farmers in one particular area may be from Chiuchow whereas in an adjacent area only Tungkwun dialect is heard.

When the success of vegetable farming became obvious many of the local farmers began to take an interest in this new line of cultivation. Instead of leaving the land fallow in the winter, between rice crops, wherever possible catch crops of tomatoes or other winter vegetables may be grown. A few of the less traditionally minded areas have swung over completely to vegetables and have allowed outsiders to rent some of the clan land.

Though many other factors in addition to soil, influence the settlement pattern, it is interesting to observe the correlation between the soils and the distribution of the various groups of people.

#### Farming Communities.

From an agricultural point of view there are three groups of people in the colony (i) Cantonese, (ii) Hakka and (iii) Immigrant farmers. Each group has a distinctive social and cultural background which is reflected in the farming methods and in the degree of affluence of the farmers. The Cantonese villages are, without exception, on the rich alluvial soils of the Chik Nai Ping, Mai Po and Castle Peak Associations while the Hakka villages are on the stony footslope soils of the Sun Hing, Lam Tsuen and Sek Kong Associations. On the other hand the immigrant refugees are densely packed on the high rental lands of the Fanling

Association and on the areas of recent alluvium. The distribution of the farming groups may be seen in fig. 15.

The oldest existing settlements in the New Territories are all Cantonese and many of these villages are fortified with walls and moats which seems to indicate that when the land was occupied by the Cantonese some 1100 years ago the peaceful pursuit of farming required armed protection (Plates 1 and 2). It is not at first clear against whom those early settlers protected themselves, for the land on which they built their houses and cultivated their fields must have only recently emerged from the sea. Soil profiles dug in the Chik Nai Ping Soils of the Kam Tin villages occasionally have sea shells at depths of four feet or less, and in the poorly drained profiles there are the identifiable remains of leaves which are unlikely to have persisted for more than 1000 years. It is probable that when the walled villages were built they were on or very near the coast and the settlers were the first to reclaim and cultivate these alluvial soils. It has been suggested that the Cantonese farmers dispossessed the original inhabitants who then took to the hills and harried the walled villages but it is more probable that the walls were protection against pirates. Though the soils of these villages must have been wet and salty when originally settled, they are now the richest in the colony and are all

planted to two crops of rice per year. Because of the inheritance customs and the strong clan spirit the descendants maintain the lands intact and each family has enough land to farm and can gain enough money from two crops of rice without recourse to vegetable cultivation in the winter. Most of the fields could be profitably planted to vegetables all the year round, but the families would then have insufficient labour to cultivate all their fields, and would either have to rent out part of their land, or allow it to lie fallow. Because the vegetable farmers are mostly refugee immigrants the rice farmers tend to consider vegetable growing to be an inferior trade, thus the majority of the richest soils in the colony are not fully exploited.

A detailed examination of the agricultural background to one of these villages may serve to explain many of the advantages and some of the drawbacks of the economy on the rich soils. The village of Tai Hong Wai is chosen as being fairly representative.

In Tai Hong Wai there are 40 families comprising 198 persons all of the Tang clan. Though they are all tenant farmers they are the traditional occupiers and the landlord is a descendant of Tang Hon Fat who came to the district in AD 973.<sup>■</sup> Rental of the fields is at the rate

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■ Sung Hok Pang Legends & Stories of the New Territories  
H.K. Naturalist 1935.



of 3 piculs of rice for each dau chung and it is possible to harvest 6 piculs per dau chung each year. Each farming family has an average of 14.6 dau chung and some families have as much as 40 dau chung so that there is quite a considerable turnover and reasonable profit from rice alone. Very slowly, of recent years, these traditional farmers have been converted to the profitability of vegetable growing, and six or seven farmers grow vegetables in the winter in addition to two crops of rice. The pattern of the fields has been set for centuries and the inheritance laws have involved an unfortunate dispersion of holdings, e.g. one farmer with 6 acres of land divided into 10 separate fields, has to walk more than three miles to visit each of his fields. This dispersion is very uneconomic but it is an advantage in that it tends to prevent one farmer having all his fields in the best soil and another member of the clan inheriting only drier and poorer land. The average yield of rice in the Chik Nai Ping soil of Tai Hong Wai is 3 piculs per dau chung per crop, but if vegetables are grown in the winter the residual effect of the vegetable fertiliser may raise the yield to 4 piculs per D.C. so that not only do the vegetable crops bring in cash, they add considerably to the yield of the rice crop. Unfortunately, vegetable growing is low in the social scale besides being very laborious so that these Cantonese farmers on the richest soil in the

colony do not make the fullest use of their land.

Though almost all of the village land is on the high yielding poorly drained series of the Chik Nai Ping Association, the fields close to the village have the highest yields due to natural fertiliser in the form of village waste, and straw ash. Straw ash is the traditional fertiliser and has been applied regularly through the centuries so there is a plentiful supply of potash in the soils, but there is a good response to nitrogen. If vegetables have been grown in the field in the winter and nitrogen is applied to the rice at the rate of 50 lbs. sulphate of ammonia per D.C. the yield may be as high as 539 catties per D.C. in each of two crops of paddy per year, but the normal yields range from 300 to 400 catties per D.C. Before the war, the average crop of paddy was 250 catties and the increase to the present figure of 350 is due largely to the work of the Department of Agriculture in making improvements in seed and in insecticides and in fostering appreciation of the value of artificial fertilisers.

Methods of farming, dates of sowing, inheritance of tenancies and water rights are all governed by tradition which is a strong factor in preventing a more intensive use of the land.

The Hakka farmers occupy the more steeply terraced, coarser textured and stony soils of the foothills. These soils belong to the Sek Kong, Sun Hing and Sha Tin Associations. The rice yield on these soils is generally low and the average is from 2 to 3 piculs per D.C. per year. However, these farmers have the advantage that they never suffer from the floods which are frequent in the lower lying areas, also they have control of the upper reaches of the streams so that they can normally divert sufficient water for irrigation without too much trouble. Furthermore they have adjacent hillside for forestry lots, grass cutting, and grazing.

Because they occupy restricted sites along narrow valleys, on spurs and on footslopes the typical Hakka village is long rather than square, with a "fung shui" grove of trees behind, and a small fish pond in front of the village. From among many such typical Hakka villages one was chosen at random and a survey made of the farming economy.

The village of Chuk Hang is on the western footslopes of Tai Tau Yan mountain (Plates 3 and 4) and is on soils of the poorly drained series of the Sek Kong Association. All the village fields are planted to two crops of rice and the average annual yield is 2-3 piculs per D.C. but, though the soil is poorer than in the Kam Tain area the

villagers here are nearly as prosperous as those in Tai Hong Wai for more than half of the villagers own the land they cultivate. Of the fifty families in Chuk Hong there are 20 families who own their own land and 17 who are tenants. The average holding is 9 D.C. per family which is appreciably less than in the Kam Tin villages. One would assume that on the poorer soils and with the smaller size of farm these people would be considerably poorer than their Cantonese neighbours but the differences are not too extreme, for the Hakkas have a more diversified economy.

Most of the abandoned paddy fields in the hilly areas were farmed by Hakka and even today these farmers travel long distances to fields in remote valleys. These remote fields tend to be uneconomic under present conditions and more than half of the adult males in Chuk Hang no longer work on the land but have employment elsewhere. In all of the Hakka villages the field work is done almost entirely by the women.

As in Kam Tin the soil is improved if winter vegetables are grown in the paddy fields but the yield and range of crops at Chuk Hang is limited by the poorer soil and less favourable situation. However, sweet potatoes grow well and these are used as pig feed.

The sandy loam soils of Chuk Hang respond well to fertilizer but all three of the major elements, N,P, and K



are required to raise the yield to 3 or  $3\frac{1}{2}$  piculs per D.C. per crop. This soil would respond well to organic fertiliser and if vegetables were grown with liberal application of nightsoil over a prolonged period the soil could be built up to give higher yields of rice. In this area it would be profitable to follow a 3 year rotation to improve the soil e.g.

1st year - Vegetables

2nd year - 2 crops paddy and winter vegetables

3rd year - 2 crops paddy

However the Hakka people, like the Cantonese are very conservative and while they do not have quite such a strong prejudice against vegetable growing, the Chuk Hang villagers require practical demonstration before they will accept new farming ideas.

In sharp contrast with the traditional farmers are the refugees who have come, many from Chiuchow and Tungkwun, bringing new ideas and new methods. In their original homes many of these people were paddy farmers but in coming to Hong Kong they have had to conform to local conditions of shortage of land, good road and rail communications, a large urban population, and plentiful supply of nightsoil. Not all of these refugees were penniless and many set themselves up in rural districts as pig and poultry breeders or as vegetable farmers. Though they come from many parts

of China and have settled in established rural areas they are in such large numbers and form such unified groups through Co-operative Marketing organisations that they form a powerful factor in the rural economy.

Vegetable growing on a large scale is a postwar development in the colony and owes its origin to the phenomenal increase in population of the Urban area. There was created a tremendous market for fresh vegetables, fostered by the difficulties in obtaining supplies from China. The population increase was mainly due to the influx of refugees and many of these had been skilled farmers elsewhere in China. Those farmer refugees who had a little capital cashed in on the market gardening boom and created an overcrowding problem which is almost insoluble. The best land for vegetables is all on the Fanling Association, and on recent alluvium along streams. Pre-war the rents for these areas was 3 piculs but the farmers let and sublet to the market gardeners at rents of 5, 6 or 7 piculs and the land is apportioned at an average of 2 D.C. per family so that there is often excessive subdivision. However there is no dispersion of holding. The crops are valuable and might be easily stolen so each family lives on its own piece of land. Thus we have shanty town conditions and huts scattered thickly over the best and most valuable land. This is not only uneconomical but

presents a considerable health risk because there are no sanitary provisions and open nightsoil storage pits are everywhere (Plate 13). Furthermore the land is so valuable that few farmers risk using some of their allotment for pigsties which might help to broaden the economy and cushion the periodic losses involved in vegetable farming. Fortunately most of the vegetable farmers belong to Co-operatives and form quite a powerful body so that loans, fertiliser and technical advice are readily available. Though the soils are very rich they are required to produce up to eight crops per year and heavy applications of fertiliser are required. The most favourable soil has a surface horizon of good tilth underlain by clay, or with a weakly permeable iron pan to assist surface flooding when required. Soils which have been subjected to paddy cultivation, are tailor made to fit these requirements, for paddy farming tends to make the surface soil lighter in texture than the subsoil and a hard pan is developed on all but the most poorly drained paddy fields. In the Fanling-Sheung Shui area where there is the greatest development of vegetable farming the predominant soil is the black clay of the Fanling Association and even where the soils are mapped as Chik Nai Ping they may be underlain by this black clay. Not all of the Fanling Association soils are suitable for vegetables because the clay is often sticky, heavy, and difficult to work; fortunately however, most of these

Fanling soils have a surface horizon of 5-10" evidently derived from a different source than the black clay and normally having a loam or silt loam texture. Farmers on such soils can get particularly high yields of vegetables though the work is unremitting and there are considerable marketing risks. Night soil is applied in a fluid form and the vegetables require frequent watering. If the soil is too heavy there is surface caking and the fertiliser does not penetrate, on the other hand if the soil is too sandy it dries out and the nightsoil is washed away before it can be assimilated. A silt loam is the most desirable texture and the organic content of the soil is gradually built up. The vegetables are grown on beds or wide ridges built up from the Apg horizon of former paddy soil and the ridges are bordered by interconnecting furrows dug to the depth of the paddy hardpan. Occasionally these furrows are flooded and a long wooden container (Tang tsai - small boat) containing nightsoil is floated along the furrows and the fertiliser is ladled on to the plants. Other fertilisers including feathers, lime, and synthetic fertilisers are used but nightsoil is the main ingredient. By these methods the soil is, in the first instance, improved but there are some indications that long term results may not be so good due to accumulation of toxic residues in the soil, plant diseases, and insect pests.



This is particularly true where there is no rotation of vegetable crops and Chinese white cabbage is grown continuously. To overcome problems such as these, some of the more conscientious vegetable farmers grow one crop of rice every three or four years in the belief that the soil changes resultant on flooding and paddy cultivation may remedy the defects brought on by continuous vegetable cropping. However this intensive cultivation of vegetables is a comparatively recent development and it is too early to assess the nature of the soil changes which occur.

### Crops

**Rice:** There has been a steady decrease in the acreage under paddy over the past 20 years but rice is still the most important crop in respect of the area it occupies. By careful selection of early flowering varieties, and by planting nurseries for the second crop while the first crop is still in the field, it is possible to grow two rice crops per year. In the first crop all of the varieties appear to be intermediate between Japonica and Indica species and require 115-125 days growing period. There is, however, a trend towards the more early maturing (90 days) varieties which may be planted a fortnight later than the normal rice crops so that the winter catch crop may have a longer growing period. In the beginning of

July the second crop is sown in nursery beds and the first crop is harvested. Because of the shorter daylight in September and October, when the second crop is ripening the indica varieties are preferred, with a growing period of 135-150 days.

In most areas artificial or organic fertiliser is applied to the nursery and in some of the more progressive districts the transplanted crop is given a top dressing of chemical fertiliser (ammonium sulphate). Response to fertiliser is fairly uniform in showing a lack of nitrogen. Where the soils are very poorly drained and the irrigation water is partially stagnant there is a slight response to potash. Phosphate is very seldom lacking.

A very small acreage (245 acres) of upland rice is grown during the first crop period (March-July) in the higher rainfall area in the extreme eastern peninsulas of the Colony, but yields are small and the area under this crop is rapidly declining.

A very large area (2,900 acres) mainly around Deep Bay is planted to brackish water paddy in the second crop period (July-Nov.) but though the yield may be fairly high the quality of the rice is poor. The soils in the brackish water rice area are mainly silty clay or silty clay loam texture and the high salt content causes extreme hardening

and cracking in the winter so that it requires all the rains of the first half of the summer to wash out or dilute the salts before the soil may be ploughed and the rice transplanted in August. All of the nursery seed beds for the brackish water paddy are in fresh water areas so that the seedling may be sufficiently robust to withstand transplanting to brackish water.

The area of fresh water paddy could be extended if sufficient irrigation water could be made available to wash out the salts from brackish areas and if the bunds around Deep Bay could be provided with efficient sea gates to prevent flooding by sea water at high tide.

Vegetables; In some respects it may be said that any soil can be made to support crops of vegetables provided adequate fertiliser is applied. Along Castle Peak road several small fields may be seen with good crops of lettuce or cabbage grown on sea sand. The best and most varied crops of vegetables are grown on the black soil of Fanling Association. Such is the variety of vegetables grown and the rapid adaptations to a fluctuating market, it is difficult to describe a typical rotation. Indeed some farmers avoid any attempt at crop rotation but grow Chinese white cabbage continuously; six or seven crops per year, every year. The more normal procedure is to

plant according to market demand with a general emphasis on Chinese vegetables in the summer months and European type vegetables in winter. A great amount of labour is involved in weeding, watering, and fertilising the crops and more than 25% of the farmer's annual budget is spent on fertilisers including nightsoil, ash, bonemeal, duck feathers, lime and artificial fertiliser. The main requirements of the soil are that it should have a loamy surface horizon which can be easily worked and which does not cake under repeated watering. The subsoil should be a clay with a high water table though the hardpan residual from paddy cultivation is equally useful in maintaining the irrigation water at the correct depth.

Sweet Potatoes: On the drier soils all the year round, and as a catch crop on the free and imperfectly drained series paddy soils, sweet potatoes are grown, both for the tubers and for the vines. The vines and small proportion of the tubers are fed to pigs and the remainder of the tubers sold for human consumption. Sweet potatoes are particularly suited to the variable rainfall conditions of Hong Kong for the growing period may be as short as 8-12 weeks if there is adequate rainfall or over 8 months in periods of drought. The only drawback of this crop is its susceptibility to frost damage which sometimes occurs



in the northern part of the Colony.

**Sugar Cane:** This is grown to a limited extent on the drier soils, mainly in the Ping Shan area. All of the crop is consumed locally as a confection or dessert, none is processed and sold as sugar. The cane is cut in early winter and two ratoon crops are obtained in addition to 1 main crop.

## CHAPTER VIII

### VEGETATION, EROSION AND AFFORESTATION

The barren hillsides of the New Territories present a dry and xerophytic impression contrasting oddly with the intensively farmed, densely populated lowlands. Such total absence of trees from the hillsides rather suggests that the original vegetation cannot have been altogether different from the existing savannah or grassland. However, from soil evidence and climatic analogues, it seems highly probable that the hills were originally clothed with evergreen tropical rain forest.

With the demands for prevention of erosion, protection of catchment areas and provision of firewood, the question of the climax vegetation of the hillsides assumes a practical rather than an academic aspect. If the natural conditions favour a savannah cover and if the hills of Hong Kong have never been forested, it is somewhat unlikely that Man will be able to establish trees where Nature has failed. Only by careful analysis of soil, climate and botanical data can we decide whether afforestation is a feasible proposition in the New Territories.

From analyses of hill soils (Appendix I) it is apparent that, though the level of plant nutrients is

generally low, there is no chemical reason why trees could not thrive on most of the hillsides. There are, however, physical factors in the soils, which could limit the growth of trees. Many of the in situ soils on the Tai Mo Shan Porphyries and on volcanics of the Rocky Harbour, Repulse Bay and Port Shelter Formations have very dense compact subsoils which tend to inhibit root penetration. Furthermore, many of the lithosols developed on the granites and on the Pat Sin Conglomerates<sup>m</sup> and quartzites, have very little surface material in which tree seedlings could establish. It is very apparent when walking over the 'Hammerhead' to the north of the entrance to Plover Cove that no trees would ever grow there because the quartzite provides barely enough surface material for grass or lichens to establish. Less than 9% of the uplands can be classed as lithosol and not all of the lithosols are completely unfavourable for trees. It is very difficult to assess the degree of resistance that a soil material presents to tree root penetration. Many of the pines growing on the North Downs at Lok Ma Chau appear to be thriving on a few inches of soil and strong roots have penetrated the rock material (C horizon) for more than two feet in some cases. The local pine (*Pinus Massoniana*) and the *Casuarina (equisetifolia)* thrive best on loose soils, but in recent plantations at Pat Heung the trees are growing reasonably vigorously in

spite of the compact, in situ, subsoil.

In general it must be assumed that there is no pedological factor which would prevent afforestation of at least 80% of the hill areas of the New Territories. To this rather negative information may be added the positive evidence of previous forest cover in several of the hill soil profiles from Lantau and Tai Mo Shan. The B. horizons of these profiles frequently show broad streaks of upper horizon material carried down to depths of more than 5 feet along former root channels. Though it is possible that some form of woody shrub might have been responsible for these root channels, none of the existing shrubs develop roots of such thickness or penetration, and there can be little doubt that the brown streaks signify a former woodland cover.

It may be argued that the climate of this region is not suitable for afforestation. It is obvious that amongst the climatic agencies it could be only the rainfall which, either by absolute insufficiency or by an unfavourable distribution, could be responsible for the original absence of forests. The temperature factor though varying markedly in different parts of the colony due to elevation and exposure, could not set a limit to forest growth though it does affect floristic changes within the vegetation cover.



Since there are no remnants of original vegetation, the possibility of a forest cover under existing climate conditions can only be inferred through comparison with forested areas elsewhere in the world where a strictly comparable climate exists. The most exact climatic analogues are provided by Hainan and Assam and it has been stated in publications of the Institute of Botany, Peking (Academica Sinica, 1956), that the tropical rain forest of Hainan is a remnant of the forest which formerly covered the whole of coastal Kwongtung and Kwangai. However, the climatic data for Hainan are scanty and it is necessary to pursue the analogy on the basis of the Assam figures. In Sibsagar, Assam, the climatic conditions harmonise so well with the data for Hong Kong that the occurrence of primeval, evergreen rainforests there can certainly be taken as indicative at least of the general suitability of this climate, for the development of luxuriant rain forests.

TABLE VIII (a) See Over .....

TABLE VIII (b) See Over .....

TABLE VIII (a)

COMPARISON of the CLIMATIC ELEMENTS of HONG KONG & SIBSAGAR

Average Annual Temperature	Monthly Average Temperature °C		Rainfall		Days of Rainfall		Rel. Humidity %		Cloud Cover	
	Max.	Min.	Annual (mm)	Max. Min.	Max. Min.	Max. Min.	Max. Min.	Max. Min.	Max. Min.	Max. Min.
H.K. 22.0	28.2 July	14.7 Jany.	2150	41 June 2 Jan.	21 July 5 Dec.	84 65	April Nov.	79 53	April Nov.	
Sib. 22.6	27.6 July	14.3 Feby.	2370	40 July 1 Dec.	22 July 3 Dec.	85 79	Sept. Mar.	88 46	July Dec.	

TABLE VIII (b)

COMPARISON of the RAIN CLIMATE of HONG KONG & SIBSAGAR

MONTH	Monthly Rainfall (mm)		Percentage Distribution	
	Hong Kong	Sibsagar	Hong Kong	Sibsagar
January	32	29 )	6.9	8.5
February	44	55 )		
March	72	120 )		
April	137	251 )	37.9	37.6
May	288	291 )		
June	391	359 )		
July	373	404 )	47.1	46.6
August	367	414 )		
September	271	299 )		
October	103	131 )	8.1	7.3
November	44	28 )		
December	20	15 )		
	2148	2396	100.0	100.0

The reason for the close coincidence of the climatic figures for Assam and Hong Kong is the regime of the monsoon climate, but such strict homology is unusually striking and should be indicative of other similarities of the two regions. The climatic coincidence expresses itself inter alia in the vegetation. In the mountains of Assam and N.E. India at elevations greater than 5000 feet there is the same type of *Quercus-Castanetum* vegetation which occurs in the higher areas of Kwangtung; trees which are found in the tropical rain forest in Assam, grow very well in Hong Kong once they have become established, though they tend to suffer from competition with grasses and woody shrubs at the seedling stage.

The following lists of plants give further proof of the near floristic relation between the forests of the Himalayas and the trees and shrubs of Hong Kong and Kwangtung.

SPECIES (see over) .....



SPECIES

Eastern Himalayas (1500-400 m.)

*Acer caesium*

*Prunus padus*, *P. nepalensis*

*Ulmus wallichiana*

*Pinus longifolia*, *P. khasia*,  
*P. mercusii*

*Podocarpus neriifolia*

*Berberis* spp.

*Phyllanthus emblica*

*Pteris ovalifolia*

*Daphne cannabina*

Sibsagar

*Michelia champaca*, *M. montana*

*M. oblonga*

*Artocarpus chaplasha*

*Cinnamomum cecicodaphne*

*Altingia excelsa*

Hilly areas of Hong Kong

*A. rutteri*, *A. tanceolatum*,  
*A. reticulatum*.

*P. mume*, *P. japonica*, *P.*  
*macrophylla*, *P. Marginata*.

*U. parvifolia*

*P. massoniana*

*P. weriifolia*, *P. chinensis*,  
*P. argotaenia*

*Berberis* spp.

*P. emblica*, *P. urinaria*,  
*P. simplex*, *P. anceps*.

*P. ovalifolia*, *P. swinhoei*

*D. cannabina*, *D. champoi*

Lower altitudes in Hong Kong

*M. yuscata*, *M. maudiae*,  
*M. alba*, *M. champeca*

*A. integrifolia*, *A. hypergraea*,  
*A. heterophyllus*

*C. parthenoxylon*, *C. leylandicum*

*C. camphora*, *C. burmanni*, *C. cassia*

*C. eduncalatum*

*A. chinensis*

The existing natural vegetation in Hong Kong is distinctly poor. On the sandy beaches there is usually a scrubby belt of screw pine with patches of caesalpinia and in the undergrowth.

Spinifex, Vitex, Crinum or Belamaanda with occasional clumps of prickly pear (Opuntia). On the muddy beaches and particularly round Deep Bay there is a dwarf mangrove formation formed by Rhizophoraceae, Aegiceras and various Cyperaceae.

Beside each of the villages there is a 'Fung Shui' grove mostly comprised of old Banyan trees (Ficus Retusa) but there may be clumps of bamboo. Around the rice fields there are many species of Desmodium, Solanaceae, Amaranthaceae, Chenopodiaceae as well as adhesive seeded Compositae and water loving weeds such as Scrophulariaceae.

The mountainsides where they are not scarred by erosion are clothed with grasses. In the higher levels such as the tops of Tai Mo Shan, Lautau Peak and Ma On Shan the turf is largely Ischaemum app. containing ground orchids, Balsams and mountain Compositae. On the middle and lower slopes the grass is coarser with patches of Melastomaceous and Ericaceous under-shrubs, Acanthaceae, Hedyotes, Lilium longiflorum and Platycodon.

In the gullies which are saved from grass fires by their rocky character and their moist soil, there are abundant shrubs, ferns and flowers such as *Rhodomyrtus*, *Melastoma*, *Gordonia*, *Gardenia*, *Mussaenda*, *Strophanthus*, *Raphiolepis*, *Pittosporum*, *Lespedeza*, *Eurya*, *Zanthoxylum*, *Diospyros*. In the more rocky and damp ravines are found various epiphytic orchids, Gesneriaceae, and herbaceous Urticaceae.

There is a tremendous variety of tree species, particularly on Hong Kong Island but it is difficult to say which of these species are endemic to the region.

### Erosion

One of the most striking features of the Hong Kong countryside is the erosion of large expanses of granitic and other hills. In some of the worst of the eroded valleys in the Castle Peak area the landscape has a lunar starkness, with its lack of vegetation. the painful reflection of sunlight, tortuous gullies and almost no permanent streams. Though the serious erosional features are all on granitic material, there are some small patches of denuded hillside on the volcanic areas. Three problems arise in connection with this erosion.

- (a) What is the nature of the erosion and why is it so serious on granite soils?
- (b) What are the causes of erosion in Hong Kong?
- (c) What can be done to prevent further erosion?

It is the purpose of this section of the Memoir to attempt to answer these questions.

#### Nature and extent of erosion in Hong Kong

Almost all of the granite areas may be described as eroded in so far as there are no complete soil profiles with fully developed A. horizons. It is the spectacular gully erosion which draws attention to the denudation but even in the porphyritic granite area in North Lantau where there is relatively little open gullying, the soil surface is covered with quartz grit and the tufts of grass are three to six inches apart. A complete profile on this material would be a Red-Yellow Podsollic soil with the sequence

A / A / A / B / B / C.  
0 1 2 2 3

Such profiles have been found in the Red-Yellow Podsollic soils on volcanic material and very infrequently they may be found on sheltered, colluvial deposits derived from granite. For the most part the granitic soils have a modified  $A_2/B_2/B_3/C$  horizon sequence



and it appears that the surface material has been lost by dehydration, deflation, and surface wash. The dehydration has been caused both by natural and by human agencies. Owing to the sparsity of the vegetation and the lack of any form of shade for the soil, temperatures of up to  $40^{\circ}\text{C}$  may be recorded on the soil surface and  $36^{\circ}\text{C}$  at a depth of six inches, thus there may be severe desiccation accentuated by the open porous fabric of the granitic soils. Further dehydration of an even more extreme form arises from the local practice of frequently burning-off the grassy vegetation to promote a healthier growth of the hardier shrubs, which are gathered as fuel by the villagers. When the surface soil has been dried up to a powder by the intense insolation and grass burning, the wind is able to whip up all but the coarse quartz grains and even they tend to gather, by saltation, around surface boulders. Frequently it happens that the soil surface may be covered quite thickly by accumulations of grit, and change of local environment, such as gully erosion, landsliding, or boulder slipping, provides material which is washed in over the quartz. Later excavation reveals the grit as a stone line or a succession of "stone lines" (fig. 32). The more normal method of stone line formation is by progressive erosion of the soil surface, i.e. the finer surface material is washed or blown away leaving quartz grains and small stones but the

soil is subjected to rapid alternations of soaking and desiccation so that a pattern of polygonal cracking develops and the stones or grits fall down the cracks to accumulate as a layer at a depth of four to six inches. A third form of stone line occurs when in situ parent material containing quartz veins is acted on by normal soil processes. All of the less resistant rock minerals are broken down and profoundly altered but the quartz is relatively unaltered save for moderate disintegration and coating with iron oxides. Organic matter develops and accumulates in the A horizon and the heavier quartz grains are found at the junction with the B horizon.

Surface quartz grit, quartz "Stone lines", and polygonal cracking of the soil surface are common features in areas where the A horizons have been eroded by wind or surface wash. Grasses with roots extending into the B horizon (*Eriachne pallescens*, *Gahnia tristis*) tend to prevent development of the more serious gully erosion but frequently the presence of a grass cover, however sparse, conceals widespread surface denudation.

Sheet erosion of the type described above is general throughout the granite areas but its occurrence may be classified as in the following (Table VIII(c)).

TABLE VIII (c) 1. CHARACTERISTICS OF SHEET EROSION IN THE GRANITE AREAS

OCCURRENCE	Slope Class	Dominant Erosive Agent	Surface Features	Vegetation
Ridge tops	A (Level)	Wind (Plus footpaths)	Polygonal cracking, excessive desiccation	None
Plateaus	B (1° - 4°)	Wind & surface run-off	slight polygonal cracking, gritty surface	sparse woody shrubs
Single or complex slopes	C & D (4° - 8° and 8° - 15°)	surface run-off	No cracking, smooth bare often slippery surface. Collections of grit in lee of boulders.	sparse grasses.

### Gully erosion.

Arising from sheet erosion or ridge tops accentuated by the very rapid run-off on the slopes, severe gullying networks develop rapidly and extensively. Polygonal cracking on ridges is accompanied by two very important soil characteristics (a) relatively rapid percolation and (b) sudden and strong expansion of the polygonal blocks, accompanied by displacement, on wetting. These features are responsible for initiation of gullying.

During dry periods in the heat of summer the blocks, or prisms of soil are dried out with gaps of  $\frac{1}{2}$  -  $\frac{3}{4}$ ". Dust, stones and grit fall into the cracks so that when the rain comes and the wetted soil expands there is a tendency for horizontal displacement of the prisms. A further complication is added by resistance that the baked soil aggregates offer to wetting. Frequently in the heaviest downpours the prisms are coated with thin covering of silty clay mud but the interior remains dry and hard, so that the blocks become to a certain extent separated from the mass of the soil and form a loosely interlocked capping which may be easily dislodged. (Fig. 29). While the capping remains intact little damage may be done and the soil may appear to be highly permeable, but when one or two of the blocks are removed the vulnerable subsoil is exposed to rain and



run-off water so that gully erosion is initiated.

There are various types of gully reflecting different characteristics of the subsoil but almost all of the gullies in Hong Kong have one feature in common in that they all arise from polygonal cracking in the ridges and spread downwards. There is little or no headward expansion and this has an important bearing on the nature of the gullies for they grow by vertical cutting and lateral slumping, but seldom increase in length.

Many factors influence the shape or cross-section of the gullies, but in general they follow a regular pattern through youth, and maturity to old age.

The youthful gully is born during a high intensity rainfall of short duration. Almost immediately it attains its full length extending from the polygonal block crust of the ridge top to the break of slope at the foot of the hill, in a straight line but with sudden sharp changes of direction where stones cause potholing of the subsoil. At this stage the gully is little more than a very narrow slit with vertical sides and a flat bottom, except where potholing has occurred and the cross-section is onion shaped (fig. 29). In its youth also the gully achieves its maximum depth and then enters into maturity.

In maturity the gully is at its most destructive phase. Vertical cutting is no longer possible and the water can only cut laterally. An oval cross section is developed but almost immediately the undercut walls collapse so that the gully assumes a 'U' section. Widening proceeds from the lower end of the gully to the ridge top, several parallel gullies may coalesce and the erosion scar is a wide V in plan view.

Old age in a gully begins when there is deposition on the gully floor and gully walls become progressively less high and less steep until the whole feature becomes little more than a scoop shaped depression. At this stage in its life history the cutting is affected more by long steady rain and thorough soaking of the soil (causing slumping of the walls), than by short showers of high intensity.

Considerable space has been devoted to a description of the life cycle of gullies in the granitic districts because it is important to estimate the age of this present erosion cycle. One of the larger gullies at present entering its third or old age of development is 61 feet deep and 120 feet wide but one of the local villagers aged 77 claims that it was narrow enough to step over when he was 7 years old. On this evidence there are few gullies that date back more than 100 years. Mr. D.C. Shen of the

Forestry department is carrying out a precise series of observations on depth and rate of soil removal from which he estimates that open erosion began not more than 120-150 years ago.

It cannot be assumed, however, that erosion of the granite soils of Hong Kong is associated solely with some disastrous change in the land utilisation pattern 150 years ago. Rather the present erosion phase is the culmination of a whole series of events starting more than 1000 years ago.

#### Causes of Erosion.

An inquest on the Soil Erosion of Hong Kong requires careful examination of four material witnesses (1) Geology (2) Soil (3) Climate and (4) Vegetation.

#### Geology of Eroded Areas.

Most of the geological data on weathering of granite is derived from an excellent study by Ruxton and Berry (1957). From examination of many deep vertical sections exposed in building excavations in Kowloon it has been established that the local granite weathers by a process of "onion scaling". Percolating water penetrates along cracks in the rock and attacks the outer layers of core stones, breaking down the minerals in the order: biotite, plagioclase orthoclase.

When the minerals are disintegrated the rock texture is destroyed as in fig. 31 (b) and only quartz remains unaltered. The granite develops a weathering profile (fig. 31 (a) ), and may be profoundly altered to depths of more than 100 feet. Thus plenty of material is provided for erosion. Not all of this material can be properly classed as soil and it is in the top three or four feet that the main changes take place leading to extensive gullying.

#### Soil of Eroded Areas.

A uniform deeply weathered material such as that provided by deep weathering of granite and described above, would be unlikely to develop gullies because the percolation rate is high and the most serious erosion that could be expected would be surface wash or soil slip. However the developed soil profile introduces other factors, affecting the permeability of the material and introducing differentiation of the surface layers.

Red yellow podsollic profiles elsewhere in the Colony conform closely to the standard definition (Chap.IV) but in the granitic areas a hard pan develops in the  $A_2/B_2$  horizons. Though this hardpan is partly cemented by materials washed down from surface horizons, there is strong reason to suspect that precipitation and dehydration of  $SiO_2$  may also be involved. The indurated layer lacks iron staining and



the pH of the pan is slightly lower than that of surface horizons so it is unlikely that iron or aluminium could be precipitated to provide cementation. Silice hardpans have been noted by Marbut (1935) and by Nikiforoff (1942) but there has been very little work on this type of formation.

Red yellow podsollic soils similar to those in Hong Kong are found in Tennessee (Winters, 1942), but there the hardpan is massive and occurs at depths of 18" - 24" whereas in Hong Kong it is seldom deeper than 6" - 12" and is normally strongly prismatic or columnar in structure. These discrepancies proved rather disconcerting until it was realised that the Hong Kong profiles had been truncated and that the organic horizons were no longer complete. Sheet erosion had washed off 6-8" of topsoil and exposed the hardpan to more severe drying out. Where the Red-Yellow Podsollic profile is found complete with a reasonable topsoil as, for example, in some of the more sheltered valleys, the hardpan is developed at depths of 12-20" but is less strong in-duration than in the eroded profiles and the structure is massive with no sign of the vertical cracking which is so characteristic of the surface induration.

It may seem strange that induration is held to be cause of soil erosion but there can be little doubt that it is the most important single factor. In the initial stages

the hardpan prevents more serious erosion by limiting the surface wash to the top 12" of the profile, but once the indurated layer itself is exposed to insolation and direct impact of rainfall, surface cracking develops, and the runoff water is channeled so that it exerts greater erosive power. Once the hard surface crust is penetrated by a stream of rain water the softer subsoil is very easily eroded and gullies develop by deepening, undercutting, and slumping.

The mechanism of silica hardpan formation and the nature of the clay minerals involved in the slumping of the B<sub>3</sub> horizon, have not yet been fully investigated but it is unlikely that erosion can be arrested unless steps are taken to prevent development of these characteristics in the soil profile.

The normal answer for prevention of erosion is afforestation and it is interesting to observe the effect of vegetation on the soils subject to erosion in Hong Kong.

#### Vegetation of Eroded Areas.

In the worst of the eroded areas there is of course no vegetation but on north and east facing slopes where gullying is less active there is quite a varied cover of coarse grasses ferns and woody shrubs.

The litter from these plants is seldom of any benefit to the soil, partly because of surface wash and partly because, being woody or evergreen, they are slowly and with difficulty absorbed into the soil. In plantations of pine and casuarine (*P.massoniana* and *C. equisetifolia*) incompatibility of soil and litter is even more noticeable and it is doubtful whether pine needles will be conducive to formation of a non-erodible soil profile. On the contrary, the available evidence indicates that pine litter reinforces the tendency towards podsolisation.

#### Climate and Human Factors.

There are many indications that climate and microclimate have a controlling share in the distribution of erosion in Hong Kong. Strangely enough rainfall in its spatial or annual distribution does not appear to be the most important climatic factor. The most serious erosion occurs in the granitic soils to the West of Tai Lam Chung and Castle Peak, but these areas have the lowest rainfall in the colony. (fig. 6). On the other hand, there is relatively little gullying on the structurally similar granite soils of North Lantau even though the rainfall on Lantau is greater than that of Castle Peak. Insolation is probably the most effective single climatic factor affecting extent of erosion. Granitic hill slopes

which face south and south west are exposed to the full glare of the sun. When the surface soil has been removed, the excessive insolation has a profound baking effect on the hardpan and causes polygonal cracking. There is significantly less cracking and a considerably better vegetation cover on north facing slopes. Even in the worst of the eroded area severe gullying is restricted to the slopes with a southern aspect. Where erosion is slight the north facing slopes have a much larger proportion of grasses in their vegetation cover compared with a preponderance of woody shrubs on the southern slopes, (fig.30).

When the excessive insolation has prepared the soil for erosion, the rain is able to do its work. In Hong Kong the rainfall is largely in the form of high intensity showers associated with thunderstorm clouds of great vertical extent, particularly in the summer months when the temperatures are high enough to produce immediate baking of the wetted soil crust (Table VIII (d) ). Furthermore, these short, but heavy summer rains have a marked diurnal pattern with a maximum in the morning so that soil which has been soaked by rain in the forenoon is exposed to the unshaded heat of the sun for the afternoon.



TABLE VIII (a) Maximum Intensity of Rainfall with Associated Maximum Temperatures & Sunshine Hours.

Month	Max. Rain	Temp. Mean Max. °F	Total Sunshine	Month	Max. Rainfall	Temp. Mean Max. °F	Total Sunshine
January	5.2 in./hour	64.5	95.3 hours	July	8.54 in./hr.	88.9	210.2 hrs.
February	4.25 in./hour	63.4	140.6 "	August	12.60 in./hr.	87.6	226.2 "
March	5.67 in./hr.	72.3	88.3 "	Sept.	12.00 in./hr.	86.9	174.7 "
April	5.95 in./hr.	80.2	167.8 "	October	3.62 in./hr.	81	226.1 "
May	9.13 in./hr.	85.1	172.2 "	Novr.	4.17 in./hr.	75.8	254.6 "
June	9.17 in./hr.	86.8	174.7 "	Decr.	2.84 in./hr.	71.5	246.8 "

Wind is a powerful agent of erosion in the early stages when the surface horizons are being removed, but when the hardpan is exposed the only duties that the wind can perform are to assist in evaporation of moisture from the soil and to keep the ridgetops swept clear of vegetation.

In mediterranean countries goats are responsible for depletion of vegetation and causing erosion, but in Hong Kong man has played an important role in the erosion story, both indirectly, by interference with the plant cover, and directly by physical removal of protective soil. The most obvious sign of human causes of gullying is the surprising occurrence of gullies along steep narrow ridges. These particular erosion scars are formed along footpaths, where the groove worn by footsteps provides a natural channel for rainwater. More serious erosion may partly be attributed to the destruction of vegetation by grass cutting, grass burning and the widespread destruction of forests.

It is partly to remedy and offset these depredations that the Hong Kong Government has embarked on a fairly ambitious programme of afforestation. In view of the nature and causes of erosion in Hong Kong, it is necessary to review the forest history of the colony.

### Afforestation

There are virtually no true forest soils in Hong

Kong. The natural vegetation of tropical rain forest which covers Hainan and which is generally conceded to have originally been a feature of the whole of South China has disappeared almost without trace from Hong Kong. Not only have the forests disappeared botanically, they have gone so long ago that there is only slight pedological evidence of a former tree cover. All of the hill soils have developed under the existing vegetation of thin grassland, low scrub and scattered pine trees.

Apart from the climatic analogy with Assam there are several statements in Chinese history which indicate that the Canton delta and the region around Hong Kong was well wooded more than 1000 years ago. At that time this area was unpopulated save for small coastal communities (Shek Pik and Lamma) and possibly a group of nomadic tribes practising a shifting cultivation in forest clearings. The coastal villagers are generally believed to have had boats large enough to carry cargo of stones for building and implements (Barnett, 1959). Presumably these boats were built of local timber of large dimensions suitable for hollowing out by fire or adze. Evidence of the inland tribes is less securely based on actual finds but it is believed that forest clearings were burnt and the land cultivated for a few years before the families moved on to the next piece of forest to be burnt and cleared.

These peoples are likely to have had affinities with the Yao tribes who live the more inaccessible mountain areas of South China, and may be the forerunners of the Hakka families (Wong, S.L. 1953).

Many causes have been cited to account for the complex<sup>tc</sup> disappearance of the jungle vegetation and all the evidence points to the colonisation of the area by the Chinese in the beginning of this millennium as the period of deforestation.

When the Chinese and Hakka villages established themselves in and around the alluvial plains, they brought with them an established civilisation and way of life that demanded stoutly built houses and temples. The forested hillsides provided building materials and firewood but it also harboured tigers, leopards, wild pigs and deer, so that for security of life and crop it may well be that the farmers adopted a determined policy of burning down the forests.

Whatever may be the reason, the cover of tropical forest vegetation was destroyed and this brought on two separate and distinct erosion cycles, one immediate and catastrophic<sup>h</sup>, and the other delayed but cumulative in its effect.

It has been noted that there is a podsollic tendency in all the granite soils and in all the other soils of



this region at altitudes greater than 1500 feet. When these podsollic soils were denuded of vegetation it is reasonable to assume that their lack of surface cohesion and exposed position on mountain tops would render them liable to erosion. There are several indications that the erosion was severe and sudden, e.g.

- (a) Boulder streams: Around the higher peaks such as Tai Mo Shan, Ma On Shan, Tai Mun Shan, Kowloon Peak and the Pat Sin range there are streams of rubble and large boulders filling pre-existing valleys (Lam Tsuen and Chuen Lung), or spreading out as boulder fans over alluvial plains (Sek Kong). The detrital materials have not been deposited for a sufficient period to allow chemical weathering to make any impression on the constituent boulders. In a road cutting in Lam Tsuen Valley, bouldery detritus up to 50 feet in depth overlies 'in situ' weathered material which is indistinguishable morphologically from present day surface soils. Such extensive, thick, and widespread deposits containing boulders up to 8-10 feet in diameter are obviously the spoil of serious erosion in the mountain peaks. There is no evidence of climatic changes which might account for such erosion and it is probable that the erosion resulted from destruction of the vegetation cover.

- (b) Soil Profiles: If it is conceded that there was a dense forest cover in this area up to 1000 years ago there are surprisingly few signs of forest soils. It is probable that the upper horizons have been depleted and this would account for the presence of broad, organic stained root channels in the lower horizons of soils which lack pronounced organic horizons.
- (c) Coastline extension: In the past few centuries there have been considerable changes in the coastline of Hong Kong. Until quite recently Castle Peak Peninsula was an island and the country town of Un Long was a sea port with an approach channel through San Hui and Ping Shan. In recent years the marshes around Deep Bay have extended considerably and as recently as 1898 a gunboat was able to steam up to Kam Tin along a creek that is now barely deep enough to accommodate a punt. It is apparent that alluvial deposition in this area has accelerated in the past 1000 years and the material no doubt derives from erosion of the deforested hillsides.

When the tropical forest was cut down, erosion and burning prevented natural regeneration of evergreen and deciduous hardwoods but the local pine (*P. Massoniana*) has shown remarkable powers of regeneration or colonisation (Frenzel 1930) in clean felled areas. It is probable that the

initial erosion was gradually overcome, a pine and grass-land vegetation. Unfortunately the acid needles of the pine do not improve the soil and tend to produce rapid podsolisation (Wright 1955). However a scattered woodland of pines became established, particularly in the granitic areas. Most of the older residents remember the Colony to have been much better wooded than it is now. Much of the pre-war timber was cut down during the Japanese occupation and by the hordes of refugees that poured into the Colony after the war. It is tempting to assert that the present deforested condition and the serious erosion are consequence of the tremendous increases in population over the past 25 years but even in areas which have been relatively untouched by influx of refugees (e.g. the Portuguese islands of Colowan and Taipa) there is a similar pattern of gullying, erosion and deforestation.

It must be concluded that the erosion of granite is not a local phenomenon caused by factors specific to Hong Kong, but is general throughout coastal Kwangtung and is part of a cycle of soil formation. The growth of pine trees, particularly on the granite areas has assisted in development of podsolisation features. When the pine trees are removed the organic and leached horizons are particularly prone to erosion by wind and rain, exposing the silica hardpan to the weather so that gullying begins.

The only way to prevent further erosion and to stabilise the gullied areas is by reafforestation.

Areas to be forested.

Many factors such as accessibility, reservoir catchment protection, fire control, and economic return, must be considered in drawing up a schedule of priorities for an afforestation programme. If soil factors alone were consulted the priorities could be drawn up as in Table VIII (e) (See next page).

It is possible that some of the hill soils, either below 1000' or in sheltered valleys above this height, may be suitable for orchards, mulberry trees, tea plantations and growing vegetables out of season (e.g. Pak Ngau Sink) so long as there are other hill soils which are more suitable for afforestation the areas with alternative land use should be left free for a more intensive land use. Such areas exist on the old terraces to the North and East of Tai Mo Shan and on the slopes of the Tai Tau Yan range.

Tea was grown on many of the north facing mountain slopes in the 1870's and a herring bone pattern of tea terraces may still be seen on these hills. When the New Territories came under British administration in 1898 the tea industry died off because of prohibitive Customs dues in Canton where the tea was sold. Lately there has been



TABLE VIII (e)

## AREAS REQUIRING AFFORESTATION FOR EROSION CONTROL AND PROTECTION.

PRIORITY	TYPE OF AREA	LOCATION OF EXAMPLES	REMARKS
Priority I	Areas badly scarred by gully erosion	Castle Peak Peninsula, Tai Lam Chung, Shing Mun & North Kowloon, Chimawan Peninsula, Chek Lap Kok Island	All granitic areas with very rapid erosion.
Priority II	Areas likely to become seriously eroded in the near future if no cover is provided	North Lantau, South Western tip of Lantau, Lamma Island	These are granitic areas where gullying is not yet serious but where erosion is likely to be developed.
Priority III	Areas subject to erosion but not to gullying	The Peninsula east of Ma On Sha to Tai Long Wan, High Island & Kuei Island.	Trees grow well in these areas
Priority IV	Areas of Pedsollic and skeletal soil	All Hill soils at altitudes of greater than 1000', e.g. Tai Ma Shan	Planting of trees in these areas will help in formation of soil and in conservation of water.
Priority V	All other areas not suitable for more intensive land use.	The peninsulas to the E. of the Colony.	

a revival of interest in the industry. Successful commercial plantations have been established on Lantau and the Department of Agriculture has begun a promising series of investigations on tea culture on Tai Mo Shan. It is unlikely that tea plantations in Hong Kong will ever rival Assam or Ceylon but a high quality, connoisseurs leaf may be cultivated here.

Types of Trees which grow successfully in  
Hong Kong

The greatest success has been with pine (*Massoniana*) but *Casuarina* (*Equisetifolia* and *Stricta*) has also been successful. Unfortunately, though both these trees grow well it is doubtful whether they are the best cover for the soil. The needle litter is very slowly absorbed into the soil complex and frequently the heavy rains wash away the litter before it has had time to produce a useful humus in the soil around the tree. Furthermore the pine litter is very acid and, though it is too early to make observations backed by scientific data, it is fairly probable that the natural podsollic tendency of the granitic soils is aggravated under pine or casuarina and a distinct hardpan is formed. The beginnings of such a hardpan have been observed in soils planted to pine round Shing Mun reservoir. Unfortunately no soil descriptions or analyses were made before the trees were planted in 1955 and 1936 so it cannot with

absolute certainty be stated that the pines are solely responsible for the hardpan formation. It is strongly recommended that before coniferous trees are planted, particularly in granitic soils, there should be a detailed survey of the soils accompanied by profile descriptions and analysis of samples, to be followed up by re-examinations of the soil and comparison of the analyses after the plantation has been established for 10 and 20 years.

If conifers are harmful to the soil and tend to produce a soil which is easily eroded when the forest is cut down, the question immediately arises; "what is the alternative?"

From examination of soils developed under broad-leaved trees (*Tristania conferta* at Tai Lung and *Aleurites Montans* at Shatin) it is apparent that the organic horizon is being augmented by tree litter and even on soil susceptible to podsolisation, as at Shatin, there is no sign of a hardpan developing.

Broadleaved trees, particularly if they are deciduous, would provide the best cover for Hong Kong soils but they are somewhat difficult to establish. When the seedlings are transplanted to the hillside the broadleaved trees appear to be less able than the pines to compete with the natural grasses. However it has been found in forestry

experimentation at Castle Peak that when the broadleaved seedlings are interplanted in an established pine plantation, they grow vigorously and quickly, because the pines have already killed off the grassy undergrowth.

On these findings it seems desirable that for proper conservation of soil and stabilisation of erosion in Hong Kong, a rotation should be practised in which plantations should be established with pine trees. After the pines have grown to heights of 6 - 10 feet a broadleaved species should be interplanted and the pines gradually thinned out and eliminated.

#### Government afforestation

After the war, in 1946, there was an urgent need for afforestation both to prevent further erosion and to make good the wartime deforestation. Government adopted an afforestation programme which has steadily gained momentum until now there are from 1000 - 3000 acres of new planting every year. Most of the government planting has been associated with the catchments for reservoirs at Shing Mun, Tai Lam Chung and Shek Pik but some of the eroded areas round Shap Long on South Lantau have been forested and villagers have been encouraged to plant forest lots with Government assistance. The main government forest areas are detailed below



Reserve	Total Area
Tai Lam	3,269 acres
Fu Shui	1,212 acres
Shing Moon	6,025 acres
Pat Heung	2,133 acres
Kowloon Hills	1,818 acres
Tai Po Kau	693 acres
Shap Long	818 acres
Tai Tam	
Shek Pik	

The areas planted to trees both by Government and villagers is shown on fig. 27, together with some indication of the distribution of scrub and thin scattered woodland.

#### Conclusion:

Several points have been discussed in relation to vegetation, erosion and afforestation and it is convenient here to summarise the contents of this chapter.

Vegetation and Soil in this district may be said to have passed through a ten stage process over the past 1000 years.

- (a) Tropical forest as in Hai Nan and Assam.
- (b) Colonisation of alluvial plains by the Cantonese

- (c) Destruction of original forest cover
- (d) Erosion. (Formation of boulder fans at Sek Kong and Lam Tsuen)
- (e) Stabilisation of erosion and colonisation of deforested areas by pines and grasses.
- (f) Development of hardpan and podsoles under pines
- (g) Destruction of pine forests
- (h) Loss of topsoil
- (i) Gullying
- (j) Reforestation

If the woodland cover is maintained as pine forest there is every likelihood that the cycle represented by items f, g, h and i, will be repeated, but it may be possible to avoid this by establishing broadleaved forest with the following species: *Liquidamber formosana*, *Cassia fistula*, *Melia azederach*, *Pterocarpus indicus*, *Sapindus mukorossi*, *Sapium discolor*, *Sapium sebiferum*, *Sterculia lanceolata*, *Choerospondias ascellaris*, *Lagerstroemia speciosa*. The most promising of the broadleaved deciduous trees is *Tristania Conferta*.

Analytical Methods used in Hong Kong

Mechanical analysis of the soils was carried out by a modification of the hydrometer method. (Buoyoucos, 1937). Total nitrogen was determined by semi-micro Kjeldahl method using a Markham apparatus. (Markham, 1942). The method of Walkley and Black was adopted (Walkley and Black, 1934) for organic carbon. pH values of the soils were determined on 1:2.5 soil/water suspensions using a Beckman Model H meter with glass electrode. (Soil Reaction Committee, 1930). Available phosphorus was extracted with 0.1N HCl - 0.03 N  $\text{NH}_4\text{F}$  and was determined by the molybdenum blue method. (Bray and Kurtz, 1945). Cation exchange capacity and exchangeable cations were determined in a neutral normal ammonium acetate leachate, calcium and magnesium being determined by "Versenate" titration (Cheng and Bray, 1951) and potassium and sodium by flame photometric method. (Fieldes, 1951). Determination of silica,  $\text{Fe}_2\text{O}_3$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{TiO}_2$ ,  $\text{P}_2\text{O}_5$ ,  $\text{MgO}$ ,  $\text{K}_2\text{O}$  in the clay fraction was by alkaline fusion analysis. (Robinson, 1939); Silica being determined after a double evaporation with HCl;  $\text{Fe}_2\text{O}_3$  and  $\text{TiO}_2$  were determined by conventional methods, and  $\text{Al}_2\text{O}_3$  by difference.

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APPENDIX I  
Routine Analysis

Hori- zon	Depth in.	Igni- tion loss	Mechanical Analysis			Exchangeable Cations m.e./100 g.					Satur- ation	pH	Carbon	Nitro- gen	P <sub>2</sub> O <sub>5</sub>	mg/100g. Available P <sub>2</sub> O <sub>5</sub>	Remarks
			% Sand	% Silt	% Clay	Ca	Mg	Na	K	H							
Chik Nai Ping, Imperfectly drained. Kam Tin																	
Apg	1 - 5	4.56	75.8	10.1	11.8	1.66	0.61	0.13	0.12	3.21	67.2	5.0	0.91	0.085	0.143	5.3	Low available P <sub>2</sub> O <sub>5</sub> except in Apg.
B <sub>2</sub> ir <sub>1</sub>	6.-10	4.78	51.1	26.7	19.8	4.19	1.50	0.51	0.06	2.81	89.3	6.7	0.36	0.027	0.068	0.2	
B <sub>2</sub> mn <sub>2</sub>	12- 16	6.23	22.4	37.7	36.8	5.56	0.40	0.24	0.07	4.20	92.3	6.6	0.39	0.026	0.074	0.2	Low organic matter content. High percentage base saturation.
B <sub>2</sub> ir <sub>2</sub>	20 -24	7.58	15.2	37.7	43.3	6.30	2.55	0.24	0.08	3.89	91.4	6.5	0.38	0.039	0.069	0.2	
B <sub>2</sub> ir <sub>2</sub>	26 -30	5.38	39.3	29.7	28.3	4.38	1.52	0.90	0.11	1.52	92.3	6.4	0.30	0.023	0.076	0.5	
B <sub>2</sub> mn <sub>2</sub>	36 -40	4.26	49.4	25.2	23.3	4.17	1.61	0.34	0.10	3.08	94.0	6.4	0.19	0.019	0.042	0.1	
	49 -52	3.61	56.9	15.9	23.6	4.23	1.61	0.13	0.10	1.98	91.2	6.3	0.12	0.027	0.034	0.1	
Chik Nai Ping, Poorly drained. Tai Hong Wai (Kam Tin)																	
Apg	1 - 6	5.03	55.9	25.5	16.1	0.91	0.15	0.29	0.17	7.02	46.1	5.0	1.09	0.098	0.172	28.2	Silt exceeding clay in Apg and Ahg.
Ahg	9 -12	3.99	45.3	34.4	16.3	1.50	0.55	0.14	0.09	3.84	59.4	5.3	0.59	0.058	0.103	6.4	
Bg	16 -20	4.24	60.9	15.4	21.6	2.61	0.88	0.15	0.08	1.72	82.2	5.7	0.30	0.028	0.079	0.2	Low organic matter content.
Bg	24 -28	5.14	47.7	17.1	32.6	2.32	0.82	0.16	0.07	1.97	79.2	5.9	0.32	0.023	0.083	0.3	
G	33 -37	3.77	67.9	13.1	15.2	2.11	0.90	0.13	0.07	1.56	84.4	5.8	0.36	0.043	0.047	0.3	
Chik Nai Ping, Very poorly drained. Pak Wai Tsuen																	
Apg	0 - 4	6.87	45.1	28.9	22.6	1.20	2.02	0.56	0.36	6.52	61.3	5.1	1.18	0.111	0.169	6.6	High exchangeable Na in G.
G	10 -14	6.15	50.9	19.3	26.7	1.17	2.06	0.42	0.43	2.96	77.2	5.3	0.99	0.083	0.144	4.3	Exchangeable Mg exceeding Ca.
	16 -20	9.13	40.9	25.5	29.0	1.19	2.70	0.64	0.52	8.03	46.5	4.2	2.32	0.175	0.183	20.5	High carbon/nitrogen ratio in lower G.
	25 -29	9.69	43.2	45.5	46.5	1.35	2.78	0.91	0.01	20.04	11.3	3.1	2.48	0.129	0.136	13.1	
	39 -43	5.25	91.3	0.5	5.6	0.34	2.31	0.06	0.02	34.61	3.4	2.7	3.19	0.106	0.143	7.8	

Horizon	Depth in.	% Ignition loss	Mechanical Analysis			Exchangeable Cations m.e./100 g.					% Saturation	pH	% Carbon	% Nitrogen	% P <sub>2</sub> O <sub>5</sub>	mg/100g. Available P <sub>2</sub> O <sub>5</sub>	Remarks
			% Sand	% Silt	% Clay	Ca	Mg	Na	K	H							
Fanling, Freely drained, Tsung Pok Long																	
Apg	0 - 2	6.56	45.3	28.4	23.0	1.55	0.60	0.63	0.11	5.04	48.4	5.0	1.81	0.132	0.435	9.2	Low exchangeable K throughout High total P <sub>2</sub> O <sub>5</sub> in Apg.
Ahg	2 - 6	6.03	63.7	15.9	17.4	1.37	0.17	0.17	0.07	5.41	42.4	5.2	1.55	0.150	0.287	3.0	
B <sub>2</sub> iron	10 - 14	5.05	60.0	18.4	19.1	0.47	0.37	0.05	0.03	5.13	31.0	5.0	0.81	0.084	0.121	1.6	
Bg	17 - 21	4.72	53.4	22.8	21.4	0.82	2.27	0.09	0.10	5.95	88.7	5.2	0.95	0.041	0.154	3.2	
	22 - 24	2.70	77.4	8.9	11.0	0.54	0.73	0.11	0.05	6.21	68.1	5.7	1.66	0.059	0.113	6.6	
	26 - 30	0.45	90.2	3.6	5.7	0.47	0.07	0.06	0.02	Nil	100	6.3	0.13	0.003	0.031	0.2	
	32 - 36	1.34	87.8	5.0	5.9	1.25	0.81	0.16	0.09	2.03	92.1	5.8	0.70	0.021	0.054	0.1	
Fanling, Imperfectly drained, Sheung Shui cross roads																	
Apg	0 - 4	5.96	47.8	15.0	34.2	0.87	0.29	0.13	0.05	3.73	39.9	5.4	1.72	0.182	0.159	15.6	Low exchangeable K throughout High carbon/nitrogen ratio in upper Bg
Ahg	5 - 7	4.86	63.0	14.3	20.3	2.43	0.75	0.09	0.03	2.87	52.8	6.0	1.17	0.092	0.132	6.2	
Bg	10 - 14	7.64	56.6	16.7	22.9	1.95	0.94	0.40	0.07	4.03	44.2	5.8	2.34	0.082	0.168	7.8	
	22 - 26	2.62	50.8	25.5	21.1	1.22	0.92	0.23	0.06	2.62	94.1	5.9	0.10	0.014	0.058	0.9	
	32 - 36	3.08	60.5	18.6	17.8	1.21	1.11	0.24	0.05	2.94	83.6	5.9	0.22	0.016	0.049	0.2	
	40 - 44	3.62	50.0	18.5	27.9	1.17	0.90	0.08	0.06	7.79	74.0	5.6	0.17	0.017	0.019	0.1	
Fanling, Poorly drained, Ping Che																	
Apg	2 - 6	6.26	48.9	23.0	25.0	2.03	0.41	0.05	0.04	4.41	46.8	5.4	1.62	0.130	0.153	3.0	Very low exchangeable K throughout.
Ahg	8 - 12	7.98	33.3	26.5	36.2	1.82	0.21	0.05	0.05	17.82	32.2	5.1	1.76	0.089	0.112	3.9	
Bg	16 - 20	4.11	41.2	29.7	27.0	0.87	0.03	0.04	0.03	9.72	15.8	5.0	0.56	0.035	0.124	1.1	
BG	22 - 26	3.73	50.7	24.4	21.2	0.37	0.44	0.22	0.04	8.99	17.0	4.6	0.41	0.029	0.092	0.9	
BG	31 - 34	2.32	66.4	17.4	13.9	0.28	0.41	0.04	0.04	9.96	17.1	4.7	0.24	0.026	0.113	0.9	
	35 - 39	1.37	64.2	16.4	18.0	0.11	0.07	0.06	0.04	17.24	37.3	4.8	0.14	0.022	0.029	0.5	

Horizon	Depth in.	Ignition loss	Mechanical Analysis			Exchangeable Cations m.e./100 g.					Saturation	pH	% Carbon	% Nitrogen	% P <sub>2</sub> O <sub>5</sub>	mg/100g. Available P <sub>2</sub> O <sub>5</sub>	Remarks
			% Sand	% Silt	% Clay	Ca	Mg	Na	K	H							
Fanling, Very poorly drained. Ping Che																	
Ap	2 - 6	11.60	14.7	25.0	54.5	0.43	0.20	0.13	0.05	7.21	21.9	5.1	2.59	0.207	0.125	3.9	Low base status.
G	10 -14	16.05	17.4	16.4	54.2	0.83	0.51	0.05	0.04	21.02	24.2	5.5	3.25	0.171	0.132	4.5	High organic matter content in upper G.
	24 -30	14.55	0.3	13.8	78.6	1.79	0.97	0.23	0.07	16.43	50.9	5.0	2.07	0.112	0.143	2.5	
	36 -40	11.81	23.1	16.6	54.4	1.56	0.85	0.06	0.03	10.09	46.3	5.4	1.35	0.077	0.124	3.4	
	44 -48	0.34	83.2	6.0	10.5	0.27	0.51	0.44	0.02	1.07	24.8	5.7	0.08	0.007	0.053	0.7	
Sun Hing, Imperfectly drained, Lam Ti																	
Apg	0 - 3	5.04	74.5	5.9	17.1	3.77	1.31	0.57	0.51	N11 100		6.7	1.20	0.100	0.264	25.2	High exchangeable Na in Ahg, B <sub>2</sub> ir <sub>2</sub> and Bg.
Ahg	3 - 5	6.05	53.5	11.0	32.5	2.73	0.80	1.27	0.40	N11 100		6.6	0.93	0.061	0.112	2.3	
B <sub>2</sub> ir <sub>2</sub>	7 -11	13.7	50.7	12.8	29.6	2.06	1.23	1.26	0.23	4.12	88.7	5.0	0.43	0.030	0.074	1.0	High available P <sub>2</sub> O <sub>5</sub> in Apg.
Bg	14 -18	7.5	51.7	12.8	31.7	1.16	1.15	0.84	0.23	4.89	71.2	4.9	0.18	0.015	0.074	0.7	
G	23 -27	6.7	38.1	13.6	44.9	0.60	0.48	0.02	0.16	7.91	21.7	4.9	0.16	0.012	0.086	0.2	
G	32 -36	2.2	59.2	13.0	25.6	0.59	0.51	0.02	0.14	7.52	37.1	4.7	0.11	0.012	0.067	0.7	
Sun Hing, Poorly drained, Lam Ti																	
Apg	1 - 5	2.90	59.9	11.1	26.1	6.46	1.27	0.56	0.11	3.28	88.7	5.7	2.52	0.206	0.161	1.1	High organic matter content in Apg.
Ahg	6 - 9	8.45	59.2	12.8	23.8	3.42	1.05	0.43	0.04	6.41	65.1	4.9	1.96	0.155	0.098	1.7	
Bg	11 -15	6.65	62.2	11.3	23.2	2.95	0.99	0.28	0.01	6.87	45.6	4.7	1.17	0.091	0.091	0.8	Very low exchangeable K.
	17 -21	6.13	66.7	10.0	20.2	2.22	1.08	0.18	0.03	8.32	45.4	4.7	1.27	0.087	0.078	0.5	
G	25 -28	1.42	90.7	1.9	6.0	1.00	0.11	0.10	N11 15.17	17.1		4.1	0.92	0.054	0.049	0.7	
G	32 -36	6.17	73.1	8.3	15.5	3.20	0.69	0.19	0.05	22.34	38.3	3.9	1.24	0.075	0.061	0.4	



Hori- zon	Depth in.	% Igni- tion loss	Mechanical Analysis			Exchangeable Cations m.e./100 g.					% Satur- ation	pH	% Carbon	% Nitro- gen	% P <sub>2</sub> O <sub>5</sub>	mg/100g. Available P <sub>2</sub> O <sub>5</sub>	Remarks
			% Sand	% Silt	% Clay	Ca	Mg	Na	K	H							
Sha Tin, Freely drained, Hin Tin Village																	
Apg	0 - 3	7.82	69.4	6.2	20.6	1.21	0.07	0.06	0.09	4.37	34.2	5.2	2.14	0.207	0.107	2.1	Low base status in Apg and Ahg. Low exchangeable K throughout
Ahg	3 - 6	3.64	71.1	8.4	16.9	0.83	0.11	0.05	0.11	3.94	41.7	5.1	1.92	0.190	0.074	1.4	
B <sub>2ir</sub>	6 -10	12.02	43.0	6.7	44.3	2.13	0.43	0.06	0.10	2.43	89.8	5.7	0.97	0.100	0.039	0.4	
B <sub>2mn</sub>	12 -16	12.18	38.4	13.1	42.4	2.17	0.47	0.06	0.14	1.07	92.7	5.7	0.75	0.082	0.027	0.4	
	23 -27	12.45	44.3	2.7	46.8	2.22	0.54	0.09	0.11	Nil	100	5.9	0.60	0.052	0.032	0.5	
	32 -36	12.64	44.7	5.0	44.0	1.97	0.44	0.05	0.09	0.91	94.2	6.0	0.71	0.067	0.036	0.6	
Sha Tin, Imperfectly drained. Pak Tin Tsuen																	
Apg	0 - 4	5.65	71.4	6.3	19.5	0.38	0.25	0.07	0.12	3.41	41.3	5.3	1.93	0.182	0.071	1.7	Low total P <sub>2</sub> O <sub>5</sub> Low base status in Apg and Ahg.
Ahg	5 - 9	4.88	73.2	10.9	13.5	0.20	0.09	0.03	0.10	4.35	34.6	5.2	1.43	0.148	0.063	1.5	
B <sub>1</sub>	11 -15	4.32	75.2	5.8	16.8	0.78	0.26	0.04	0.07	5.41	42.7	5.3	0.71	0.079	0.031	0.7	
B <sub>2ir</sub>	16 -18	3.44	80.4	4.8	11.4	2.68	0.11	0.12	0.09	4.83	85.4	5.4	0.53	0.057	0.030	0.4	
B <sub>2mn</sub>	20 -24	3.35	76.0	8.5	12.1	1.11	0.17	0.08	0.05	5.34	74.6	5.3	0.48	0.052	0.020	0.5	
B <sub>2ir</sub>	28 -32	4.05	77.3	6.1	14.6	1.40	0.59	0.07	0.07	6.27	81.1	5.2	0.23	0.027	0.027	0.2	
Sha Tin, Poorly drained. Sha Tin Agricultural Station																	
Apg	1 - 5	5.27	76.4	8.7	12.3	1.38	0.31	0.07	Nil	3.88	36.2	4.9	1.82	0.164	0.078	2.3	Devoid of exchangeable K.
Ahg	10 -14	2.28	84.3	6.9	6.5	0.76	0.21	0.07	Nil	2.03	43.2	5.3	0.67	0.058	0.062	0.4	
BG	19 -22	2.21	86.5	4.8	6.5	0.55	0.24	0.14	Nil	2.94	38.7	5.1	0.33	0.041	0.038	0.3	



Hori- zon	Depth in.	Igni- tion loss	Mechanical Analysis			Exchangeable Cations m.e./100 g.					% Satu- ration	pH	% Carbon	% Nitro- gen	% P <sub>2</sub> O <sub>5</sub>	mg/100g. Available P <sub>2</sub> O <sub>5</sub>	Remarks
			% Sand	% Silt	% Clay	Ca	Mg	Na	K	H							
Sha Tin, Very poorly drained. Tin Sam																	
Apg	0 - 4	6.33	67.8	16.5	12.5	3.24	0.52	0.17	0.04	3.12	63.1	5.2	2.57	0.216	0.121	1.3	High organic matter content
Bg	8 -11	4.68	74.7	7.2	15.8	1.15	0.40	0.08	Nil	3.04	54.5	5.1	1.53	0.140	0.086	1.1	
BG	14 -17	11.56	46.0	13.8	34.4	1.97	0.98	0.23	0.17	8.62	33.2	4.3	2.50	0.163	0.092	2.4	High carbon/nitrogen ratio in G.
G	22 -26	13.77	46.4	15.7	31.0	2.42	0.85	0.26	0.33	10.76	43.7	4.6	4.42	0.145	0.074	2.9	Low exchangeable K in Apg and Bg.
G	30 -34	16.44	47.7	13.2	26.8	2.21	1.03	0.34	0.41	10.02	42.9	4.5	4.83	0.127	0.057	1.5	
Mai Po, Poorly drained. Ha Tsuen																	
Apg	1 - 4	6.32	58.1	19.3	19.4	5.23	2.47	0.55	0.05	7.21	53.1	4.9	1.76	0.116	0.091	0.9	Low exchangeable bases.
Ahg	6 -10	5.45	61.4	16.4	19.5	0.45	0.52	0.40	0.06	6.98	31.2	3.9	1.23	0.079	0.081	0.7	Low available P <sub>2</sub> O <sub>5</sub> .
BG	14 -18	4.62	63.4	15.0	19.3	0.32	0.68	0.09	0.11	19.87	20.5	3.4	0.91	0.066	0.047	0.2	High carbon/nitrogen ratio in BG
	23 -27	5.73	73.6	17.0	6.5	0.13	0.59	0.02	Nil	40.05	8.9	2.6	1.10	0.068	0.086	2.1	
	34 -38	5.98	67.5	27.8	6.7	0.27	1.04	0.18	0.02	46.18	11.2	2.7	1.05	0.031	0.067	2.3	
Lam Tsuen, Imperfectly drained. Lam Tsuen																	
Apg	1 - 4	4.64	47.7	12.6	37.4	0.47	0.21	0.05	0.18	3.72	42.5	5.3	1.61	0.060	0.244	26.8	Low exchangeable bases especially in Apg.
Ahg	8 -11	5.75	64.5	8.4	24.2	1.41	0.07	0.08	0.13	5.70	63.2	5.4	0.80	0.085	0.083	0.7	
B <sub>2ir</sub>	13 -17	5.45	66.1	8.5	22.7	1.23	0.11	0.15	0.11	2.89	74.7	5.9	0.73	0.076	0.075	1.1	High available P <sub>2</sub> O <sub>5</sub> in Apg.
B <sub>2mn</sub>	22 -26	6.14	66.0	13.5	17.4	1.53	0.07	0.14	0.15	1.80	87.4	6.3	0.49	0.039	0.053	0.9	
G	32 -36	6.24	64.9	9.0	23.0	1.83	0.12	0.09	0.18	0.08	93.5	6.3	0.35	0.038	0.064	0.9	

Depth in.	% Igni- tion loss	Mechanical Analysis			Exchangeable Cations m.e./100 g.					% Satur- ation	pH	% Carbon	% Nitro- gen	% P <sub>2</sub> O <sub>5</sub>	mg/100 Available P <sub>2</sub> O <sub>5</sub>	Remarks
		% Sand	% Silt	% Clay	Ca	Mg	Na	K	H							
Red Yellow podsolic, Imperfectly drained. Tai Mo Shan																
1 - 4	8.64	57.9	16.4	21.4	1.06	0.41	0.09	0.19	7.53	17.1	5.0	3.77	0.266	0.049	0.5	Very low base status throughout  Low total and avail- able P <sub>2</sub> O <sub>5</sub> . High organic matter content.
6 -10	8.94	57.4	16.2	21.9	0.69	0.30	0.07	0.08	3.93	14.3	5.0	2.51	0.134	0.047	0.4	
12 -16	7.37	51.6	23.4	21.3	0.38	0.29	0.04	0.04	1.92	13.2	5.3	1.35	0.086	0.050	0.4	
18 -22	7.88	54.9	13.4	27.8	0.16	0.23	0.03	Nil	1.53	9.5	5.0	0.74	0.047	0.053	0.3	
28 -32	7.72	59.5	17.2	19.4	0.14	0.19	0.03	Nil	1.71	14.3	5.1	0.34	0.038	0.042	0.4	
36 -40	9.09	52.6	17.2	25.7	0.15	0.19	0.04	Nil	1.59	8.2	5.1	0.63	0.052	0.041	0.6	
48 -52	7.75	59.2	17.3	19.6	0.18	0.13	0.06	0.03	1.09	12.4	5.2	0.30	0.021	0.043	0.5	
64 -68	7.17	57.3	17.5	21.6	0.20	0.14	0.03	0.03	1.38	13.1	5.3	0.27	0.023	0.037	0.3	
Red Yellow podsolic, Freely drained. Tai Mo Shan																
1 - 5	6.86	65.4	10.8	20.4	0.37	0.16	0.06	0.09	6.38	11.3	4.8	2.92	0.168	0.043	0.3	Very low exchangeable bases throughout.  Low total and available P <sub>2</sub> O <sub>5</sub> .
7 -11	6.38	62.5	12.6	21.7	0.18	0.06	0.04	0.04	7.02	7.2	4.7	1.22	0.083	0.046	0.4	
13 -16	6.27	62.1	8.7	26.1	0.16	0.08	0.04	0.02	3.97	9.0	4.9	0.70	0.054	0.041	0.2	
18 -21	6.72	54.5	14.5	27.6	0.13	0.06	0.02	0.02	4.52	12.2	5.0	0.61	0.043	0.037	0.2	
28 -32	6.39	60.8	10.7	25.3	0.13	0.04	0.04	0.04	1.87	14.7	5.0	0.47	0.035	0.032	0.2	
Krasnosem, Imperfectly drained. Sha Tau Kok																
1 - 4	9.11	43.4	23.0	29.0	0.45	0.59	0.16	0.11	3.42	34.2	4.8	2.24	0.139	0.062	0.6	Very low exchangeable Ca and K throughout. Low Total and avail- able P <sub>2</sub> O <sub>5</sub> .
6 -10	8.09	44.4	22.5	29.1	Nil	0.09	0.16	0.03	2.04	19.1	5.0	1.02	0.070	0.020	0.4	
12 -16	8.25	49.0	22.7	24.2	0.08	0.03	0.47	0.05	1.98	12.4	4.9	1.61	0.106	0.022	0.3	
20 -24	8.71	44.3	22.8	28.5	0.32	0.54	0.19	0.05	1.45	19.7	5.1	1.27	0.065	0.027	0.4	
26 -30	8.10	71.3	9.3	15.3	0.63	0.87	0.12	0.09	2.07	24.5	4.8	1.00	0.066	0.022	0.3	
36 -40	8.28	45.2	19.7	31.0	Nil	0.02	0.06	0.02	2.03	10.2	5.0	0.45	0.029	0.017	0.2	